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U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 132.

A. C. TRUE, Director.

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# FURTHER INVESTIGATIONS AMONG FRUITARIANS

AT THE

CALIFORNIA AGRICULTURAL EXPERIMENT STATION.

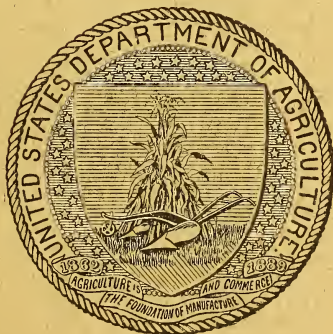
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1901-1902.

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By M. E. JAFFA, M. S.,

ASSISTANT PROFESSOR OF AGRICULTURE, UNIVERSITY OF CALIFORNIA.



WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1903.

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A. C. TRUE, Director.

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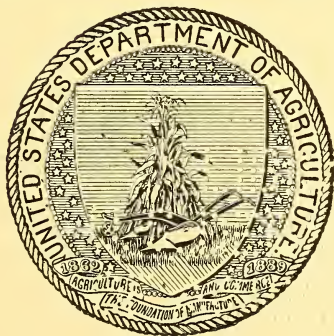
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## OFFICE OF EXPERIMENT STATIONS.

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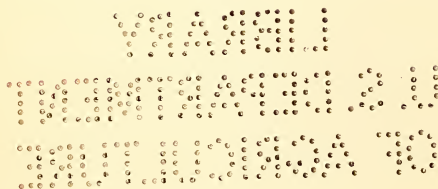
### NUTRITION INVESTIGATIONS.

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## LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,  
OFFICE OF EXPERIMENT STATIONS,  
*Washington, D. C., June 20, 1903.*

SIR: I have the honor to transmit herewith a report of investigations among fruitarians carried on at the Agricultural Experiment Station of the University of California in 1901-2 by M. E. Jaffa, assistant professor of agriculture at the University of California, and recommend that it be published as Bulletin No. 132 of this Office. The special object of this and the earlier work which it continues was a study of the value of fruits and nuts when these articles constitute an integral part of the diet. Nine dietary studies and thirty-one digestion experiments were carried on. In the majority of the dietary studies and all but one of the digestion experiments fruit and nuts constituted all or almost all of the diet. The results of the investigation emphasize the fact that both fruit and nuts should be considered as true foods rather than food accessories, a fact which is commonly overlooked.

Credit is due Prof. G. E. Colby and Mr. C. A. Friebe for assistance in the chemical work incidental to this investigation.

Respectfully,

A. C. TRUE,  
*Director.*

Hon. JAMES WILSON,  
*Secretary of Agriculture.*



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# INVESTIGATIONS AMONG FRUITARIANS IN CALIFORNIA, 1901-2.

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## INTRODUCTION.

An investigation of the nutritive value of fruits, instituted by the Office of Experiment Stations, was undertaken at the University of California in 1900-1901, and dietaries of five fruitarians—two women and three children—were studied. At the same time with one of the children—a girl—a digestion experiment was made in which fruit and nuts constituted the entire diet. A study of the income and outgo of nitrogen and the estimation of the so-called metabolic nitrogen in the feces were included in the digestion experiment. The results, which were given in an earlier publication,<sup>a</sup> showed in every case that though the diet had a low protein and energy value, the subjects were apparently in excellent health and had been so during the five to eight years they had been living in this manner.

In continuing the investigations on the nutritive value of fruits and nuts it was deemed advisable to extend the work to include, in addition to the women and children previously studied, subjects whose lives and habits differed considerably from those of the earlier investigation. Accordingly four men were selected, two being past the middle age and two young men university students. The elderly men had been more or less strict vegetarians and fruitarians for years. One of the young men had been experimenting with the fruitarian diet for several years, while the other was accustomed to the ordinary mixed diet.

The purposes of the inquiry were in brief: (1) To make dietary studies and digestion experiments in which the diet should consist exclusively or largely of fruit and nuts; (2) to obtain information regarding the practicability of maintaining nitrogen equilibrium in the body with an exclusive fruit and nut diet, and (3) to collect data on the digestibility of fruit and nuts.

In studying these problems 9 dietary studies have been made in which, with 2 exceptions, the food consisted chiefly of fruit and nuts, and 31 digestion experiments with the four subjects just referred to, in 13 of which fruit and nuts constituted the main and in 17 the entire diet.

The income and outgo of nitrogen was determined in each of the digestion experiments, and the so-called metabolic nitrogen in the feces was also studied.

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<sup>a</sup> U. S. Dept. Agr., Office of Experiment Stations Bul. 107.

## COMPOSITION OF THE FRUITS, NUTS, AND OTHER MATERIALS.

Samples of fruits and nuts and of some cereal preparations were analyzed in connection with the dietary studies and digestion experiments. The methods were those adopted by the Association of Official Agricultural Chemists.<sup>a</sup> In addition to the usual analyses, the crude fiber was determined in all samples examined as being of special interest in a fruitarian diet. The results obtained for this constituent, however, are not fully satisfactory, since the determinations of fiber in the fresh sample of fruit and in the same sample dried in the usual manner gave disagreeing results. The study of so-called crude fiber in fruits deserves to receive further attention. The heat of combustion of the feces and of many of the foods was determined at Wesleyan University, Middletown, Conn. The analytical results obtained in the present inquiry are summarized in Table 1.

Detailed descriptions of the different samples of fruits and nuts analyzed are hardly necessary. The only fruit which requires special mention is No. 201, scarlet haw, a small red fruit, from the tree of same name (*Cratægus coccinea*), which is about the size of a cherry and has a comparatively large seed. It is not commonly used as food.

Nos. 243 and 244, "Granose" and "Optasite," are wheat preparations. No. 246, "Gofio," is a combination of cereals, roasted until quite brown, and then finely ground. It is eaten dry or moistened with water, milk, honey, or fruit juice. This food product is largely used by the inhabitants of the Canary Islands. Nos. 247, "Fruit Nuts," 248, "Fruit Nuts Malted," and 249, "Malt Nuts," are also cereal preparations, and apparently the grain used has been malted during the process of manufacture.

TABLE 1.—Composition of food materials used in dietary studies and digestion experiments—composition determined.

Food materials.	Reference No.	Refuse.	Water.	Protein (N × 6.25).	Fat.	Carbohy- drates.		Ash.	Heat of com- bustion per gram.
						Sugar, starch, etc.	Crude fiber.		
FRESH FRUITS.									
Apples:		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Calories.</i>
Bellflower, edible portion . . . .	209	.....	87.54	0.64	0.65	9.77	1.11	0.29	0.249
Bellflower, as purchased . . . .	209a	16.3	73.28	.53	.54	8.18	.93	.24	.208
Newtown Pippin, edible por- tion . . . . .	242	.....	82.68	.63	.15	15.15	1.21	.18	.320
Newtown Pippin, as purchased . .	242a	12.3	72.51	.55	.13	13.29	1.06	.16	.281
Winesap, edible portion . . . . .	227	.....	88.04	.38	.42	10.02	.87	.27	.228
Winesap, as purchased . . . . .	227a	15.1	74.74	.32	.36	8.51	.74	.23	.194
Pearmain, edible portion . . . . .	229	.....	88.50	.36	.14	10.14	.61	.25	.210
Pearmain, as purchased . . . . .	229a	16.4	73.99	.30	.12	8.47	.51	.21	.176
Rhode Island Greening, edible portion . . . . .	230	.....	86.74	.48	.16	11.55	.77	.30	.237
Rhode Island Greening, as purchased . . . . .	230a	14.5	74.16	.41	.14	9.87	.66	.26	.203
Spitzenburg, edible portion . . . .	232	.....	83.75	.51	.10	14.59	.73	.32	.301
Spitzenburg, as purchased . . . .	232a	14.0	72.03	.44	.08	12.54	.63	.28	.259
Average, edible portion . . . . .	.....		86.21	.50	.27	11.87	.88	.27	.257
Average, as purchased . . . . .	.....	14.8	73.45	.43	.23	10.14	.75	.23	.220

<sup>a</sup> U. S. Dept. Agr., Division of Chemistry Bul. 46, revised.

TABLE 1.—Composition of food materials used in dietary studies and digestion experiments—composition determined—Continued.

Food materials.	Reference No.	Refuse.	Water.	Protein (N × 6.25).	Fat.	Carbohy- drates.		Ash.	Heat of com- bustion per gram.
						Sugar, starch, etc.	Crude fiber.		
FRESH FRUITS—continued.									
Bananas:		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Calories.</i>
Edible portion .....	212	.....	77.15	1.60	0.24	19.68	0.52	0.81	0.424
As purchased .....	212a	36.92	48.67	1.01	.15	12.41	.33	.51	.267
Grapes:									
Muscat, edible portion .....	202	.....	84.83	.81	.36	13.38	.42	.20	0.291
Muscat, as purchased .....	202a	14.1	72.87	.70	.31	11.49	.36	.17	.250
Tokay, edible portion .....	205	.....	87.12	.66	.15	11.36	.42	.29	.241
Tokay, as purchased .....	205a	20.9	68.92	.52	.12	8.98	.33	.23	.191
Verdal, edible portion .....	211	.....	85.06	.69	.60	12.68	.50	.47	.286
Verdal, as purchased .....	211a	22.6	65.85	.53	.46	9.81	.39	.36	.221
Cornichon, edible portion .....	207	.....	86.78	.66	.21	11.39	.60	.36	.266
Cornichon, as purchased .....	207a	23.1	66.73	.51	.16	8.76	.46	.28	.205
Average, edible portion .....	.....	.....	85.95	.70	.33	12.20	.48	.33	.271
Average, as purchased .....	.....	20.2	68.59	.56	.26	9.76	.38	.26	.217
Oranges:									
Navel, edible portion .....	236	.....	86.26	1.45	.16	10.84	.60	.69	.254
Navel, as purchased .....	236a	28.6	61.59	1.04	.11	7.74	.43	.49	.181
Navel, edible portion .....	237	.....	86.72	1.07	.20	10.84	.60	.57	.246
Navel, as purchased .....	237a	22.7	67.03	.83	.15	8.38	.46	.45	.190
Average, edible portion .....	238	.....	86.49	1.26	.18	10.84	.60	.63	.250
Average, as purchased .....	238a	25.65	64.31	.94	.13	8.06	.44	.47	.186
Pears:									
Easterbury, edible portion .....	204	.....	82.93	1.15	.72	13.30	1.48	.42	.338
Easterbury, as purchased .....	204a	21.8	64.86	.89	.56	10.40	1.16	.33	.265
Duchess, edible portion .....	224	.....	85.00	.80	.26	12.97	.70	.27	.268
Duchess, as purchased .....	224a	13.6	73.45	.69	.22	11.21	.60	.23	.232
Glout Moreau, edible portion .....	225	.....	80.60	.83	.50	16.59	1.10	.38	.379
Glout Moreau, as purchased .....	225a	20.1	64.40	.66	.40	13.26	.88	.30	.303
Winter Nelliss, edible portion .....	226	.....	76.08	1.02	.28	19.17	2.78	.67	.444
Winter Nelliss, as purchased .....	226a	27.0	55.54	.74	.20	14.00	2.03	.49	.324
Guava, edible portion .....	235	.....	80.00	1.13	.57	16.60	1.31	.39	.370
Guava, as purchased .....	235a	13.2	69.43	.98	.50	14.41	1.14	.34	.321
Average, edible portion .....	51	.....	80.92	.99	.47	15.73	1.47	.43	.330
Average, as purchased .....	51a	19.14	65.53	.79	.38	12.66	1.16	.34	.289
Japanese persimmons:									
Large Seedling, edible portion .....	203	.....	77.04	1.61	.31	19.39	.93	.72	.429
Large Seedling, as purchased .....	203a	22.4	59.77	1.25	.25	15.05	.72	.56	.333
Tane Nashi, edible portion .....	215	.....	81.93	1.16	.55	12.81	2.93	.62	.346
Tane Nashi, as purchased .....	215a	18.8	66.53	.94	.45	10.40	2.38	.50	.281
Yemon, edible portion .....	216	.....	81.66	1.32	.85	13.19	2.37	.61	.376
Yemon, as purchased .....	216a	30.7	56.59	.92	.59	9.14	1.64	.42	.261
Average, edible portion .....	52	.....	80.21	1.36	.57	15.13	2.08	.65	.384
Average, as purchased .....	52a	23.97	60.96	1.04	.43	11.53	1.58	.49	.292
Olives:									
Mission, edible portion .....	239	.....	70.33	2.44	11.13	8.81	3.64	3.65	.713
Mission, as purchased .....	239a	16.8	58.51	2.03	9.26	7.33	3.03	3.04	.593
Mission, edible portion .....	240	.....	63.68	2.52	23.01	2.52	3.05	5.22	1.080
Mission, as purchased .....	240a	18.9	51.66	2.04	18.66	2.04	2.47	4.23	.876
Average, edible portion .....	.....	.....	67.00	2.48	17.07	5.67	3.35	4.43	.897
Average, as purchased .....	.....	17.85	55.08	2.04	13.96	4.69	2.75	3.63	.735
Scarlet haws:									
Edible portion .....	201	.....	75.83	1.98	.65	18.57	2.13	.84	.468
As purchased .....	201a	20.0	60.65	1.58	.52	14.85	1.74	.66	.374
Watermelon:									
Edible portion .....	200	.....	92.17	.87	.10	6.41	.18	.27	.148
As purchased .....	200a	62.0	35.03	.33	.03	2.44	.07	.10	.056
DRIED FRUITS.									
Raisins:									
Edible portion .....	257	.....	28.47	4.55	.61	62.57	.66	3.14	1.336
As purchased .....	257a	9.5	25.77	4.12	.55	56.63	.59	2.84	1.209
Prunes:									
Edible portion .....	256	.....	29.14	2.54	.59	63.37	1.65	2.71	1.292
As purchased .....	256a	11.9	25.67	2.24	.52	55.83	1.45	2.39	1.140



TABLE 1.—*Composition of food materials used in dietary studies and digestion experiments—composition determined—Continued.*

Food materials.	Reference No.	Refuse.	Water.	Protein (N $\times$ 6.25).	Fat.	Carbohy- drates.		Ash.	Heat of com- bustion per gram.
						Sugar, starch, etc.	Crude fiber.		
CANNED FRUITS.									
Peaches, as purchased.....	228	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Calories.</i>
		.....	86.45	0.55	.....	12.20	0.37	0.43	0.247
NUTS.									
Almonds:									
Edible portion .....	249	.....	4.42	17.28	54.30	18.64	2.58	2.78	3.129
As purchased.....	249a	49.2	2.25	8.78	27.58	9.47	1.31	1.41	1.589
Blanched, as purchased .....	250	.....	4.00	17.68	54.75	19.19	1.68	2.70	3.147
Brazil nuts:									
Edible portion .....	254	.....	5.28	18.00	66.07	3.78	4.22	2.65	3.397
As purchased.....	254a	49.0	2.69	9.18	33.70	1.93	2.15	1.35	1.732
Shelled, as purchased .....	210	.....	4.33	19.78	63.31	6.00	2.96	3.62	3.125
Cocoanuts:									
Edible portion .....	231	.....	19.17	5.25	51.00	9.67	13.77	1.14	2.712
As purchased <sup>a</sup> .....	231a	32.03	13.03	3.57	34.66	6.57	9.36	.78	1.843
Pecans:									
Edible portion .....	234	.....	3.50	12.17	69.39	9.14	4.29	1.51	3.437
As purchased.....	234a	50.8	1.72	5.99	34.14	4.50	2.11	.74	1.690
Shelled, as purchased .....	233	.....	4.30	15.67	71.52	3.79	3.17	1.55	3.551
Peanuts:									
Edible portion .....	255	.....	4.88	32.64	47.33	10.61	1.98	2.56	3.040
As purchased.....	255a	32.5	3.29	22.03	31.95	7.16	1.34	1.73	2.052
Pignolias (pine nuts), as pur- chased .....	252	.....	6.13	33.70	47.00	7.47	1.55	4.15	2.976
Walnuts:									
Edible portion .....	223	.....	3.97	24.58	62.92	4.75	1.87	1.91	3.318
As purchased.....	223a	60.4	1.57	9.73	24.92	1.88	.74	.76	1.314
Nut preparation:									
Nut and fig "bromose," as pur- chased .....	258	.....	14.88	16.54	21.83	42.17	2.52	2.06	2.081
Cereals:									
Bread (St. Helena Sanitarium, Cal.), as purchased.....	208	.....	32.51	11.57	.62	54.01	.52	.77	1.344
Granose, as purchased.....	243	.....	9.56	10.94	1.03	74.39	1.82	2.26	1.775
Optasite, as purchased.....	244	.....	11.76	11.12	.44	74.58	.45	1.65	1.748
Rice, as purchased.....	245	.....	11.90	10.98	.06	76.35	.41	.30	1.718
Gofio, as purchased.....	246	.....	6.37	12.87	2.82	70.43	5.10	2.41	1.883
Fruit nuts, as purchased.....	247	.....	11.18	13.48	6.05	67.21	1.30	.78	1.870
Fruit nuts (malted), as pur- chased .....	248	.....	8.31	13.20	3.42	71.75	2.00	1.32	1.837
Malt nuts, as purchased.....	259	.....	4.74	4.46	.25	87.07	.42	3.06	1.732

<sup>a</sup> Shell and milk included in refuse.

A number of the foods were not analyzed, as it was believed their composition could be assumed with sufficient accuracy from analyses previously reported. The following table includes the data for such foods:

TABLE 2.—*Composition of food materials used in dietary studies—composition assumed.*

Food materials.	Reference No.	Water.	Protein.	Fat.	Carbohydrates.		Ash.	Energy per gram. <sup>a</sup>
					Sugar, starch, etc.	Crude fiber.		
ANIMAL FOODS.								
Beef:		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Calories.</i>
Medium fat, edible portion . . . .	1	62.7	18.5	18.0	.....	.....	1.0	2.436
Corned, edible portion . . . . .	2	53.6	15.3	26.2	.....	.....	4.9	3.076
Hamburg steak, edible portion . . .	3	65.5	19.8	13.6	.....	.....	1.1	2.095
Beef heart, edible portion . . . . .	4	62.6	16.0	20.4	.....	.....	1.0	2.558
Beef soup . . . . .	5	92.9	4.4	.4	1.1	.....	1.2	.265
Pork, ham, edible portion . . . . .	6	40.3	16.1	38.8	.....	.....	4.8	4.277

<sup>a</sup> Fuel value, not heat of combustion.



TABLE 2.—Composition of food materials used in dietary studies, etc.—Continued.

Food materials.	Reference No.	Water.	Protein.	Fat.	Carbohydrates.		Ash.	Energy per gram. <sup>a</sup>
					Sugar, starch, etc.	Crude fiber.		
ANIMAL FOODS—continued.								
Fish:		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Calories.</i>
Striped bass, edible portion.....	7	77.7	18.3	2.8	.....	.....	1.2	1,025
Lobster, edible portion.....	8	79.2	16.4	1.8	0.40	.....	2.2	.860
Milk.....	9	87.0	3.3	4.0	5.0	.....	.7	.717
Butter.....	10	11.0	1.0	85.0	.....	.....	3.0	7.948
Cottage cheese.....	11	72.0	20.9	1.0	4.3	.....	1.8	1,124
Eggs.....	12	73.2	14.0	12.0	.....	.....	.8	1,687
VEGETABLE FOODS.								
Cereals:								
Bread, corn.....	13	38.9	7.9	4.7	46.3	.....	2.2	2,657
Bread, white.....	14	32.0	7.7	1.6	58.0	.....	.7	2,844
Cake, cup.....	15	15.6	5.9	9.0	68.5	.....	1.0	3,891
Crackers, Graham.....	16	5.4	10.0	9.4	73.8	.....	1.4	4,310
Gluten flour.....	17	12.65	20.0	2.65	62.68	1.0	1.02	3,722
Oatmeal, boiled.....	18	84.5	2.8	.5	11.5	.....	.7	.628
Pie, pudding, etc.:								
Apple pie.....	19	42.5	3.1	9.8	42.8	.....	1.8	2,800
Custard pie.....	20	62.4	4.2	6.3	26.1	.....	1.0	1,830
Tapioca pudding.....	21	64.5	3.3	3.2	28.2	.....	.8	1,587
Rice custard.....	22	59.4	4.0	4.6	31.4	.....	.6	1,819
Gelatin.....	23	13.6	84.2	.1	.....	.....	2.1	3,759
Vegetables:								
Artichoke.....	24	79.5	2.6	.2	15.9	.8	1.0	.805
Beans, edible portion.....	25	58.9	9.4	.6	29.1	.....	2.0	1,632
Beans, baked.....	26	63.3	7.7	4.2	22.8	.....	2.0	1,640
Cabbage, edible portion.....	27	91.5	1.6	.3	5.6	.....	1.0	.320
Cantaloupe, edible portion.....	28	89.5	.6	.....	7.2	2.1	.6	.408
Cauliflower, as purchased.....	29	92.3	1.8	.5	4.7	.....	.7	.309
Lettuce, edible portion.....	30	94.7	1.2	.3	2.9	.....	.9	.198
Potatoes.....	31	75.1	2.6	.3	17.8	.....	1.5	1,114
Tomatoes, as purchased.....	32	94.3	.9	.4	3.3	.6	.5	.232
Fresh fruits: Pomegranates, edible portion.....	33	76.8	1.5	1.6	16.8	2.7	.6	1,014
Dried fruits:								
Apricots.....	34	29.4	4.7	1.0	62.5	.....	2.4	2,844
Figs, edible portion.....	35	22.7	4.3	.7	62.5	8.5	1.3	3,098
Dates, edible portion.....	36	38.2	2.9	.3	55.0	2.2	1.4	2,494
Dates, as purchased <sup>b</sup> .....	37	35.7	2.7	.3	51.4	2.1	1.3	2,330
Berries:								
Loganberries.....	38	85.7	1.09	.....	12.8	.....	.39	.582
Strawberries.....	39	90.4	1.0	.6	6.0	1.4	.6	.397
Raspberries, red.....	40	86.4	1.5	.....	11.7	.....	.4	.540
Preserves: Apple sauce.....	41	61.1	.2	.8	37.2	.....	.7	1,609
Nuts:								
Filbert, edible portion.....	42	3.7	15.6	65.3	13.0	.....	2.4	7,254
Hickory nuts, edible portion.....	43	3.7	15.4	67.4	11.4	.....	2.1	7,375
Peanut butter.....	44	2.1	29.3	46.5	17.1	.....	5.0	6,228
Cocoonut milk.....	45	92.7	.4	1.5	4.6	.....	.8	.342
Sugar, starch, and oil:								
Sugar.....	46	.....	.....	.....	100.0	.....	.....	4,101
Sago.....	47	12.2	9.0	.4	78.1	.....	.3	3,605
Honey.....	48	18.2	.8	.....	80.8	.....	.2	3,351
Olive oil.....	49	.....	.....	100.0	.....	.....	.....	9,304
Whisky <sup>c</sup> .....	50	.....	.....	.....	51.0	.....	.....	4,030

<sup>a</sup> Fuel value, not heat of combustion.<sup>b</sup> 6.5 per cent of refuse in this sample.<sup>c</sup> Proportion of alcohol assumed to be equivalent to 51 per cent carbohydrates.

# COMPOSITION OF FECES AND URINE OBTAINED IN DIGESTION EXPERIMENTS.

The composition of the water-free feces from the digestion experiments reported beyond (pp. 35-68) is given in Table 3, while Table 4 records the amount, specific gravity, and percentage and amount of nitrogen of the urine, the data in both cases being arranged according to subjects.

TABLE 3.—*Composition of water-free substance of feces.*

Laboratory No.	Whence obtained.	Weight of feces per day.	Nitrogen.	Protein.	Fat.	Carbohydrates.		Ash.	Heat of combustion per gram.
						Sugar, starch, etc.	Crude fiber.		
	SUBJECT W. S. M.								
	Experiment No. 388:	<i>Grams.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Calories.</i>
15	First day .....	28.85	3.79	23.70	22.30	29.27	11.46	13.27	5.434
16	Second day .....	15.00	4.05	25.31	22.56	26.22	12.67	13.24	5.290
17	Third day .....	25.40	4.50	28.15	17.72	30.38	9.35	14.40	5.104
18	Fourth day .....	58.50	3.49	21.83	26.74	28.99	10.59	11.85	5.515
18a	Average .....	31.94	3.96	24.75	22.33	28.71	11.02	13.19	5.336
	Experiment No. 389:								
19	First day .....	57.40	3.88	24.23	29.91	26.90	6.75	12.21	5.690
20	Second day .....	40.28	3.09	19.34	26.83	34.89	5.52	13.42	5.982
21	Third day .....	20.82	2.89	18.08	45.83	17.76	2.54	15.79	6.076
22	Fourth day .....	34.34	3.81	23.80	36.78	18.55	5.32	15.55	5.824
22a	Average .....	38.21	3.42	21.36	34.84	24.53	5.03	14.24	5.893
	Experiment No. 390:								
23	First day .....	31.81	4.20	26.22	28.21	21.23	11.07	13.27	5.586
24	Second day .....	63.06	3.57	22.34	30.06	23.46	9.56	14.58	5.516
25	Third day .....	30.54	3.55	22.18	29.25	27.83	7.34	13.40	5.434
26	Fourth day .....	43.10	3.56	22.26	36.07	20.94	7.57	13.16	5.839
26a	Average .....	42.13	3.72	23.25	30.90	23.37	8.89	13.60	5.594
	Experiment No. 393:								
34	First day .....	88.50	4.43	27.69	31.32	17.90	8.58	14.51	5.659
35	Second day .....	11.20	5.17	32.29	37.87	12.75	4.69	12.40	6.041
36	Third day .....	34.78	4.72	29.50	33.21	15.50	10.15	11.64	5.885
37	Fourth day .....	15.75	5.32	33.26	33.53	9.58	11.10	12.53	5.902
37a	Average .....	37.56	4.91	30.69	33.98	13.93	8.63	12.77	5.872
	Experiment No. 394:								
38	First day .....	60.30	3.82	23.89	26.39	24.94	10.40	14.38	5.478
39	Second day .....	53.50	3.02	18.90	25.17	39.24	5.29	11.40	5.828
40	Third day .....	85.00	3.39	21.17	20.98	45.09	3.47	9.29	5.676
41	Fourth day .....	34.09	3.29	20.57	21.70	45.45	3.63	8.65	5.722
41a	Average .....	58.22	3.38	21.13	23.56	38.68	5.70	10.93	5.676
	Experiment No. 396:								
46	First day .....	53.30	4.01	25.07	20.86	26.15	17.43	10.49	5.501
47	Second day .....	58.80	3.78	23.64	23.29	25.27	18.86	8.94	5.610
48	Third day .....	24.20	4.18	26.14	28.58	18.90	18.47	7.91	5.913
49	Fourth day .....	48.18	3.98	24.87	29.06	17.34	21.81	6.92	6.120
49a	Average .....	46.12	3.99	24.93	25.45	21.92	19.14	8.56	5.786
	Experiment No. 398:								
54	First day .....	39.59	3.49	21.84	35.14	17.40	16.39	9.23	6.027
55	Second day .....	33.69	3.48	21.75	32.15	17.54	19.02	9.54	5.908
56	Third day .....	49.79	2.93	18.30	25.67	21.58	26.47	7.98	5.657
57	Fourth day .....	52.38	3.12	19.48	27.85	21.67	23.44	7.56	5.778
57a	Average .....	43.86	3.25	20.34	30.20	19.55	21.33	8.58	5.842
	Experiment No. 401:								
66	First day .....	53.80	5.27	32.91	25.02	13.55	12.88	15.64	5.346
67	Second day .....	55.28	4.88	30.53	23.36	18.61	15.72	11.78	5.574
68	Third day .....	41.17	5.48	34.26	25.16	15.39	14.11	11.08	5.810
69	Fourth day .....	70.98	5.94	37.10	21.52	12.62	17.02	11.74	5.630
69a	Average .....	55.31	5.39	33.70	23.77	15.04	14.93	12.56	5.590

TABLE 3.—Composition of water-free substance of feces—Continued.

Laboratory No.	Whence obtained.	Weight of feces per day.	Nitrogen.	Protein.	Fat.	Carbohydrates.		Ash.	Heat of combustion per gram.
						Sugar, starch, etc.	Crude fiber.		
	SUBJECT W. S. M.—cont'd.								
	Experiment No. 403:	<i>Grams.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Calories.</i>
74	First day .....	69.70	5.27	32.93	19.67	21.78	11.19	14.43	5.326
75	Second day .....	68.70	4.55	28.44	38.70	18.64	4.88	9.34	6.344
76	Third day .....	47.55	5.29	33.04	37.10	15.35	5.10	9.41	6.314
77	Fourth day .....	34.60	4.35	27.16	32.43	23.93	5.66	10.82	5.990
77a	Average .....	55.14	4.87	30.39	31.97	19.93	6.71	11.00	5.994
	Experiment No. 405:								
82	First day .....	47.07	4.33	27.04	16.55	28.41	14.48	13.53	5.242
83	Second day .....	47.49	4.58	28.65	23.21	25.36	11.82	10.96	5.704
84	Third day .....	30.00	4.97	31.04	21.70	28.50	7.26	11.50	5.310
85	Fourth day .....	35.20	4.39	27.47	34.10	21.04	5.27	12.12	6.138
85a	Average .....	39.94	4.57	28.55	23.89	25.83	9.71	12.03	5.598
	Experiment No. 406:								
86	First day .....	20.49	4.89	30.57	21.49	30.12	5.60	12.22	5.566
87	Second day .....	65.00	5.11	31.94	26.74	20.88	8.21	12.23	5.852
88	Third day .....	29.40	4.93	30.84	33.08	20.46	3.90	11.72	6.080
89	Fourth day .....	50.50	5.33	33.33	30.90	18.09	4.68	13.00	5.970
89a	Average .....	41.35	5.06	31.67	28.05	22.39	5.60	12.29	5.867
	Average of averages.	44.52	4.23	26.43	28.09	23.08	10.61	11.80	5.732
	SUBJECT C. P. H.								
	Experiment No. 391:								
27	First day .....	20.30	4.61	28.81	19.84	33.07	5.32	12.96	5.374
28	Second day .....	17.60	4.14	25.93	12.30	44.64	4.25	12.89	5.139
29	Third day .....	19.50	4.40	27.50	8.93	49.50	2.31	11.76	4.938
29a	Average .....	19.13	4.38	27.41	13.69	42.40	3.96	12.54	5.150
	Experiment No. 392:								
30	First day .....	54.00	4.72	29.49	21.37	24.52	7.32	17.30	5.063
31	Second day .....	2.79	4.94	30.87	16.14	26.98	7.26	18.75	4.663
32	Third day .....	30.00	4.42	27.64	12.81	35.84	5.38	18.33	4.935
33	Fourth day .....	85.24	3.99	24.94	30.27	26.30	3.03	15.46	5.829
33a	Average .....	43.01	4.52	28.23	20.15	28.41	5.75	17.46	5.122
	Experiment No. 395:								
42	First day .....	29.38	3.98	24.87	23.09	27.82	9.45	14.77	5.510
43	Second day .....	38.49	4.00	25.02	19.40	29.11	10.93	15.54	5.437
44	Third day .....	65.78	3.66	22.85	29.09	28.59	6.68	12.79	5.751
45	Fourth day .....	30.41	4.08	25.52	25.86	34.96	3.19	10.47	5.924
45a	Average .....	41.02	3.93	24.57	24.36	30.12	7.56	13.39	5.655
	Experiment No. 397:								
50	First day .....	69.86	4.78	29.88	21.32	25.01	8.27	15.52	5.268
51	Second day .....	79.51	5.22	32.65	31.90	18.15	5.88	11.42	5.938
52	Third day .....	9.10	5.92	37.02	41.49	9.27	2.59	9.63	6.528
53	Fourth day .....	56.98	4.77	29.79	46.43	1.61	2.14	20.03	6.613
53a	Average .....	53.86	5.17	32.33	35.29	13.51	4.72	14.15	6.087
	Experiment No. 399:								
58	First day .....	38.99	4.69	29.28	21.11	26.96	10.14	12.51	5.314
59	Second day .....	43.52	4.81	30.04	30.97	16.13	12.89	9.97	6.189
60	Third day .....	35.48	4.49	28.03	40.92	14.20	5.47	11.38	6.603
61	Fourth day .....	44.49	4.00	25.02	48.93	8.72	5.83	11.50	6.897
61a	Average .....	40.62	4.50	28.10	35.48	16.50	8.58	11.34	6.252
	Experiment No. 400:								
62	First day .....	37.79	5.49	34.33	18.18	23.07	7.70	16.72	5.259
63	Second day .....	83.58	4.60	28.74	23.75	27.50	4.82	15.19	5.648
64	Third day .....	26.20	5.16	32.23	22.85	27.73	4.91	12.28	5.880
65	Fourth day .....	28.90	4.70	29.35	26.21	31.73	2.34	10.37	6.273
65a	Average .....	44.12	4.99	31.16	22.75	27.51	4.94	13.64	5.765

TABLE 3.—Composition of water-free substance of feces—Continued.

Laboratory No.	Whence obtained.	Weight of feces per day.	Nitrogen.	Protein.	Fat.	Carbohydrates.		Ash.	Heat of combustion per gram.
						Sugar, starch, etc.	Crude fiber.		
	SUBJECT C. P. H.—cont'd.								
	Experiment No. 402:	<i>Grams.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Calories.</i>
70	First day .....	36.99	4.96	30.97	20.27	27.01	9.44	12.31	5.804
71	Second day .....	52.98	4.48	27.99	16.88	29.10	11.35	14.68	5.714
72	Third day .....	55.98	4.61	28.78	35.57	18.35	3.58	13.72	6.046
73	Fourth day .....	59.40	3.99	24.92	41.65	18.32	2.44	12.67	6.538
73a	Average .....	51.34	4.51	28.17	28.59	23.19	6.70	13.35	6.025
	Experiment No. 404:								
78	First day .....	90.82	3.17	19.78	15.94	35.95	12.50	15.83	5.383
79	Second day .....	30.79	2.80	17.52	17.33	38.20	10.04	16.91	5.425
80	Third day .....	37.40	4.13	25.78	21.85	28.79	6.16	17.42	5.564
81	Fourth day .....	23.30	4.20	26.25	15.48	39.20	4.61	14.46	5.748
81a	Average .....	45.58	3.58	22.33	17.65	35.54	8.33	16.16	5.530
	Experiment No. 407:								
90	First day .....	15.50	3.77	23.59	22.21	31.81	6.04	16.35	5.350
91	Second day .....	36.70	3.60	22.48	22.99	28.75	10.42	15.36	5.605
92	Third day .....	65.80	3.83	23.96	25.43	32.12	4.19	14.30	5.598
93	Fourth day .....	55.80	4.45	27.78	23.48	32.79	3.52	12.43	5.810
93a	Average .....	43.45	3.91	24.45	23.53	31.37	6.04	14.61	5.591
	Experiment No. 408:								
94	First day .....	38.00	3.37	21.04	16.18	37.92	7.24	17.62	4.975
95	Second day .....	78.00	3.74	23.39	19.97	29.57	12.52	14.55	5.354
96	Third day .....	45.00	4.37	27.30	16.52	33.70	10.82	11.66	5.410
97	Fourth day .....	103.50	4.32	27.02	18.37	30.00	9.30	15.31	5.062
97a	Average .....	66.13	3.95	24.69	17.76	32.79	9.97	14.79	5.200
	Experiment No. 409:								
98	First day .....	28.60	4.09	25.53	16.23	30.62	11.04	16.58	4.829
99	Second day .....	29.50	4.15	25.96	19.19	32.16	8.99	13.70	5.309
100	Third day .....	32.30	4.56	28.51	28.40	26.90	3.93	12.26	5.780
101	Fourth day .....	72.80	4.75	29.71	30.53	22.21	4.57	12.98	5.744
101a	Average .....	40.80	4.39	27.43	23.59	27.97	7.13	13.88	5.415
	Experiment No. 410:								
102	First day .....	56.50	3.99	24.93	25.22	24.56	10.90	14.39	5.400
103	Second day .....	50.80	3.92	24.47	17.04	34.08	10.37	14.04	5.144
104	Third day .....	55.88	4.15	25.92	13.68	34.85	11.89	13.66	4.962
105	Fourth day .....	66.70	4.26	26.59	13.96	33.65	10.44	15.36	4.822
105a	Average .....	57.47	4.08	25.48	17.47	31.79	10.90	14.36	5.082
	Experiment No. 411:								
106	First day .....	30.53	4.26	26.61	19.55	35.22	5.56	13.06	5.134
107	Second day .....	52.48	4.40	27.48	42.87	13.83	5.13	10.69	4.444
108	Third day .....	34.40	3.82	23.90	37.90	22.61	6.00	9.59	6.224
108a	Average .....	39.14	4.16	26.00	33.44	23.89	5.56	11.11	5.934
	Experiment No. 412:								
109	First day .....	29.10	3.67	22.96	35.80	21.95	6.49	12.80	6.272
110	Second day .....	118.00	3.16	19.72	17.91	44.25	7.52	10.60	5.736
111	Third day .....	54.00	2.80	17.50	24.62	40.83	7.76	9.29	6.098
112	Fourth day .....	83.66	2.97	18.55	31.80	33.32	6.58	9.75	6.132
112a	Average .....	71.19	3.15	19.68	27.53	35.09	7.09	10.61	6.060
	Experiment No. 413:								
113	First day .....	36.00	3.68	23.02	28.05	26.07	6.92	15.94	5.861
114	Second day .....	129.30	2.71	16.96	26.73	38.58	7.92	9.81	6.324
115	Third day .....	48.00	2.69	16.84	24.73	43.24	6.33	8.86	6.365
116	Fourth day .....	69.20	2.98	18.60	24.05	39.92	6.88	10.55	5.962
116a	Average .....	70.62	3.01	18.86	25.89	36.95	7.01	11.29	6.128
	Experiment No. 414:								
117	First day .....	60.00	3.43	21.41	33.84	24.12	8.22	12.41	5.987
118	Second day .....	45.80	3.37	21.09	21.44	37.88	8.04	11.55	5.641
119	Third day .....	96.48	3.03	18.93	24.89	39.91	7.07	9.20	6.049
120	Fourth day .....	81.06	3.01	18.82	26.00	33.36	11.04	10.78	5.834
120a	Average .....	70.84	3.21	20.06	26.54	33.82	8.59	10.99	5.878



TABLE 3.—*Composition of water-free substance of feces—Continued.*

Laboratory No.	Whence obtained.	Weight of feces per day.	Nitrogen.	Protein.	Fat.	Carbohydrates.		Ash.	Heat of combustion per gram.
						Sugar, starch, etc.	Crude fiber.		
	SUBJECT C. P. H.—cont'd.								
	Experiment No. 415: <sup>a</sup>	<i>Grams.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Calories.</i>
121	First day .....	31.80	4.36	27.22	9.30	39.48	11.45	12.55	4.932
122	Third day .....	105.50	4.86	30.39	7.22	38.02	14.62	9.75	4.885
122a	Average .....	45.77	4.61	28.81	8.26	38.75	13.04	11.15	4.908
	Average of averages, omitting experiment No. 415.....	49.89	4.09	25.56	24.61	29.43	7.05	13.35	5.680
	SUBJECT A. V.								
	Experiment No. 416:								
123	First day .....	81.14	4.03	25.18	26.12	28.49	5.45	14.76	6.054
124	Second day .....	72.36	3.83	23.91	21.32	33.30	6.67	14.80	5.735
125	Third day .....	117.70	3.53	22.09	23.64	35.60	6.12	12.55	5.493
126	Fourth day .....	115.30	4.09	25.53	23.42	33.54	4.46	13.05	5.849
126a	Average .....	96.63	3.87	24.18	23.63	32.73	5.67	13.79	5.783
	SUBJECT J. E. R.								
	Experiment No. 417:								
127	First day .....	71.67	3.85	24.08	37.90	24.75	3.04	10.23	6.442
128	Second day .....	62.28	3.67	22.92	38.30	25.04	4.07	9.67	6.382
129	Third day .....	55.22	3.98	24.86	31.88	29.63	3.80	9.83	6.210
130	Fourth day .....	39.50	4.09	25.55	27.49	32.59	3.84	10.53	6.144
130a	Average .....	57.17	3.90	24.35	33.89	28.00	3.69	10.07	6.295
	Experiment No. 418:								
131	First day .....	41.41	4.04	25.27	27.76	31.60	4.43	10.94	6.198
132	Second day .....	72.38	3.64	22.73	39.86	22.94	3.09	11.38	6.474
133	Third day .....	51.50	3.57	22.34	45.73	15.54	4.26	12.13	6.506
134	Fourth day .....	66.84	3.83	23.95	32.97	27.17	4.50	11.41	6.266
134a	Average .....	58.03	3.77	23.57	36.58	24.31	4.07	11.47	6.361
	Average of experiments Nos. 417 and 418 .....	57.60	3.84	23.96	35.23	26.16	3.88	10.77	6.328
	Average of 30 experiments, omitting No. 416.....	48.30	4.14	25.88	26.05	27.19	8.34	12.54	5.716
	Average of 31 experiments .....	49.86	4.13	25.83	25.97	27.37	8.26	12.58	5.718

<sup>a</sup> Three-day experiment; no feces passed on second day.

Table 4 summarizes the analytical data for the urine, the results having been determined in connection with the studies of the balance of income and outgo of nitrogen reported beyond pp. 35-68.

TABLE 4.—*Amount, specific gravity, and nitrogen of urine.*

Laboratory No.	Whence obtained.	Total amount.	Specific gravity.	Nitrogen.	
				Per cent.	Grams.
	SUBJECT W. S. M.				
	Experiment No. 388.	<i>Grams.</i>			
14	First day .....	1,314	1.011	0.470	6.18
15	Second day .....	1,512	1.008	.331	5.00
16	Third day .....	1,554	1.009	.281	4.37
17	Fourth day .....	1,312	1.009	.239	3.14
	Average per day .....	1,423	1.009	.328	4.67



TABLE 4.—*Amount, specific gravity, and nitrogen of urine*—Continued.

Laboratory No.	Whence obtained.	Total amount.	Specific gravity.	Nitrogen.	
	SUBJECT W. S. M.—continued.				
	Experiment No. 389:	<i>Grams.</i>		<i>Per cent.</i>	<i>Grams.</i>
20	First day .....	1,326	1.012	0.426	5.62
21	Second day .....	1,264	1.0115	.421	5.35
22	Third day .....	930	1.011	.449	4.18
23	Fourth day .....	709	1.0135	.511	3.62
	Average per day .....	1,057	1.012	.444	4.69
	Experiment No. 390:				
25	First day .....	1,267	1.0135	.403	5.11
27	Second day .....	1,269	1.015	.471	5.98
29	Third day .....	1,219	1.016	.474	5.78
31	Fourth day .....	1,240	1.012	.404	5.01
	Average per day .....	1,249	1.0141	.438	5.47
	Experiment No. 393:				
36	First day .....	1,832	1.012	.343	6.28
37	Second day .....	1,217	1.014	.464	5.65
38	Third day .....	857	1.020	.593	5.08
39	Fourth day .....	816	1.020	.653	5.33
	Average per day .....	1,180	.....	.474	5.59
	Experiment No. 394:				
40	First day .....	1,215	1.013	.453	5.50
41	Second day .....	1,138	1.016	.645	7.34
42	Third day .....	1,018	1.018	.822	8.37
43	Fourth day .....	1,167	1.015	.717	8.37
	Average per day .....	1,135	.....	.652	7.40
	Experiment No. 396:				
52	First day .....	1,680	1.012	.380	6.38
53	Second day .....	1,269	1.015	.386	4.90
54	Third day .....	1,215	1.013	.442	5.30
55	Fourth day .....	1,266	1.013	.387	4.97
	Average per day .....	1,358	.....	.397	5.39
	Experiment No. 398:				
56	First day .....	1,963	1.012	.354	6.95
57	Second day .....	2,028	1.014	.318	6.45
58	Third day .....	1,622	1.014	.326	5.29
59	Fourth day .....	1,179	1.0165	.397	4.68
	Average per day .....	1,698	.....	.344	5.84
	Experiment No. 401:				
64	First day .....	1,518	1.012	.382	5.80
65	Second day .....	1,357	1.013	.393	5.33
66	Third day .....	1,500	1.014	.409	6.14
67	Fourth day .....	1,270	1.016	.525	6.67
	Average per day .....	1,411	.....	.425	5.99
	Experiment No. 403:				
76	First day .....	1,825	1.014	.376	6.86
77	Second day .....	1,424	1.017	.556	7.92
78	Third day .....	1,319	1.015	.508	6.70
79	Fourth day .....	1,325	1.019	.616	8.16
	Average per day .....	1,473	.....	.503	7.41
	Experiment No. 405:				
84	First day .....	1,518	1.012	.332	5.04
85	Second day .....	1,558	1.012	.473	7.37
86	Third day .....	1,315	1.012	.371	4.88
87	Fourth day .....	1,257	1.014	.481	6.04
	Average per day .....	1,412	.....	.414	5.83
	Experiment No. 406:				
88	First day .....	1,619	1.012	.332	5.37
89	Second day .....	1,276	1.013	.404	5.15
90	Third day .....	884	1.0165	.589	5.21
91	Fourth day .....	1,276	1.013	.536	6.84
	Average per day .....	1,264	.....	.446	5.64
	Average of averages .....	1,333	.....	.436	5.81

TABLE 4.—*Amount, specific gravity, and nitrogen of urine*—Continued.

Laboratory No.	Whence obtained.	Total amount.	Specific gravity.	Nitrogen.	
	SUBJECT C. P. H.				
	Experiment No. 391:	<i>Grams.</i>		<i>Per cent.</i>	<i>Grams.</i>
26	First day .....	717	1.024	0.640	4.59
28	Second day.....	1,177	1.024	.413	4.86
30	Third day .....	528	1.016	.488	2.58
	Average per day.....	807	1.021	.497	4.01
	Experiment No. 392:				
32	First day .....	1,238	1.015	.441	5.46
33	Second day.....	820	1.0245	.609	4.99
34	Third day .....	625	1.025	.902	5.64
35	Fourth day.....	1,067	1.016	.435	4.64
	Average per day.....	937	.....	.553	5.18
	Experiment No. 395:				
44	First day .....	766	1.021	.675	5.17
45	Second day.....	634	1.022	.712	4.51
46	Third day .....	776	1.021	.543	4.21
47	Fourth day.....	614	1.023	.665	4.08
	Average per day.....	697	.....	.644	4.49
	Experiment No. 397:				
48	First day .....	1,656	1.010	.389	6.44
49	Second day.....	642	1.019	.561	3.60
50	Third day .....	863	1.015	.497	4.29
51	Fourth day.....	863	1.015	.441	3.81
	Average per day.....	1,006	.....	.450	4.53
	Experiment No. 399:				
60	First day .....	1,317	1.013	.321	4.23
61	Second day.....	915	1.017	.512	4.69
62	Third day .....	1,717	1.010	.405	6.95
63	Fourth day.....	1,176	1.014	.389	4.58
	Average per day.....	1,281	.....	.399	5.11
	Experiment No. 400:				
68	First day .....	1,198	1.015	.469	5.62
69	Second day.....	654	1.0215	.696	4.55
70	Third day .....	644	1.023	.659	4.24
71	Fourth day.....	854	1.017	.573	4.89
	Average per day.....	838	.....	.575	4.82
	Experiment No. 402:				
72	First day .....	1,052	1.012	.332	3.49
73	Second day.....	1,016	1.016	.496	5.04
74	Third day .....	1,118	1.016	.529	5.91
75	Fourth day.....	1,067	1.016	.518	5.53
	Average per day.....	1,063	.....	.469	4.99
	Experiment No. 404:				
80	First day .....	1,157	1.015	.508	5.88
81	Second day.....	1,437	1.012	.376	5.40
82	Third day .....	1,036	1.016	.480	4.97
83	Fourth day.....	1,177	1.015	.513	6.04
	Average per day .....	1,202	.....	.464	5.57
	Experiment No. 407:				
92	First day .....	1,238	1.015	.728	9.01
93	Second day.....	1,020	1.020	.703	7.17
94	Third day .....	1,219	1.016	.565	6.89
95	Fourth day.....	1,299	1.015	.458	5.95
	Average per day .....	1,194	.....	.607	7.25
	Experiment No. 408:				
96	First day .....	947	1.018	.831	7.87
97	Second day.....	715	1.022	.932	6.66
98	Third day .....	819	1.024	1.044	8.55
99	Fourth day.....	728	1.025	1.147	8.35
	Average per day .....	802	.....	.980	7.86

TABLE 4.—*Amount, specific gravity, and nitrogen of urine*—Continued.

Laboratory No.	Whence obtained.	Total amount.	Specific gravity.	Nitrogen.	
SUBJECT C. P. H.—continued.					
Experiment No. 409:		Grams.		Per cent.	Grams.
100	First day .....	1,797	1.015	0.441	7.92
101	Second day .....	1,472	1.015	.441	6.49
102	Third day .....	1,217	1.014	.398	4.84
103	Fourth day .....	1,520	1.013	.343	5.21
Average per day .....		1,502	.....	.407	6.11
Experiment No. 410:					
104	First day .....	1,050	1.020	.824	8.65
105	Second day .....	1,480	1.014	.497	7.35
106	Third day .....	1,122	1.020	.697	7.82
107	Fourth day .....	1,720	1.012	.454	7.81
Average per day .....		1,343	.....	.589	7.91
Experiment No. 411:					
108	First day .....	554	1.026	.977	5.41
109	Second day .....	1,159	1.017	.512	5.93
110	Third day .....	472	1.027	.641	3.03
Average per day .....		728	.....	.658	4.79
Experiment No. 412:					
111	First day .....	936	1.018	.550	5.15
112	Second day .....	938	1.020	.500	4.69
113	Third day .....	755	1.021	.450	3.40
114	Fourth day .....	1,036	1.016	.570	5.91
Average per day .....		916	.....	.523	4.79
Experiment No. 413:					
115	First day .....	898	1.020	.936	8.40
116	Second day .....	757	1.023	.638	4.83
117	Third day .....	1,443	1.016	.369	5.32
118	Fourth day .....	1,058	1.017	.512	5.42
Average per day .....		1,039	.....	.577	5.99
Experiment No. 414:					
119	First day .....	750	1.014	.596	4.47
120	Second day .....	554	1.026	.988	5.47
121	Third day .....	877	1.020	.623	5.46
122	Fourth day .....	1,250	1.016	.573	7.16
Average per day .....		858	.....	.657	5.64
Experiment No. 415:					
123	First day .....	1,680	1.012	.432	7.26
124	Second day .....	712	1.017	.760	5.41
125	Third day .....	480	1.021	.957	4.59
Average per day .....		957	.....	.601	5.75
Average of averages omitting experiment No. 415.		1,014	.....	.549	5.57
SUBJECT A. V.					
Experiment No. 416:					
126	First day .....	1,949	1.015	.690	13.45
127	Second day .....	1,734	1.014	.552	9.57
128	Third day .....	1,424	1.017	.716	10.20
129	Fourth day .....	1,084	1.023	.876	9.49
Average per day .....		1,548	.....	.690	10.68
SUBJECT J. E. R.					
Experiment No. 417:					
130	First day .....	557	1.031	1.304	7.26
131	Second day .....	776	1.021	.922	7.16
132	Third day .....	412	1.030	1.338	5.51
133	Fourth day .....	480	1.032	1.585	7.61
Average per day .....		556	.....	1.240	6.89
Experiment No. 418:					
134	First day .....	436	1.039	1.994	8.69
135	Second day .....	374	1.038	1.978	7.40
136	Third day .....	437	1.041	1.794	7.84
137	Fourth day .....	410	1.026	1.277	5.23
Average per day .....		414	.....	1.760	7.29
Average of averages of experiments Nos. 417 and 418 .....		485	.....	1.462	7.09

## THE DIETARY STUDIES.

The subjects of the dietaries here reported include seven different persons—two elderly men, two young men university students, a woman, and two children. With the exception of the students all were accustomed to the diet, having been vegetarians for years and having limited their diet quite largely to fruit and nuts. One of the students, though accustomed to the ordinary diet, had been experimenting with vegetarian and fruitarian diet for some time. Three of the subjects, i. e., the two students and one of the elderly men, ate three meals a day at the usual hours. The others ate but twice, their first meal being taken between 10 and 11 a. m. and the second between 5 and 6 p. m. The diet included a large assortment of fresh fruits with considerable quantities of dried fruit and nuts. Honey and olive oil were also eaten, and cereals were used to a small extent in some of the dietaries, and in four cases (dietaries Nos. 355, 357, 360, and 361) some animal foods were consumed, which were limited, however, to a little milk and eggs in dietary No. 357, and to a small quantity of cottage cheese in dietary No. 355.

### DIETARY STUDY OF A FRUITARIAN (NO. 355).

The study began October 21, 1901, and continued for twenty days. The subject was a man 63 years old, weighing 124 pounds. The number of meals eaten was sixty, or three per day.

The subject had lived upon the fruitarian diet for upward of twenty years, and, while he had at times used cooked vegetables and cereals, he believed that a diet of ripe and sweet fruits with nuts agreed with him best. During the experimental period the subject walked from 4 to 8 miles a day, besides working a little at gardening.

The results of this study are given in Table 9. The figures in parentheses after each food material in this and the succeeding tables of dietary studies refer to corresponding figures in the first column in Tables 1 and 2, thus indicating the values used in calculating the amounts of nutrients of the food.



TABLE 5.—*Weights and cost of food and nutrients consumed in dietary study No. 355.*

Kinds, amounts, and cost of different food materials.	Cost and composition of food per person per day.					
	Cost.	Protein.	Fat.	Sugar, starch, etc.	Crude fiber.	Fuel value.
ANIMAL FOOD.						
Cottage cheese, 279 grams, 12 cents (11) .....	<i>Cents.</i> 1	<i>Grams.</i> 2.92	<i>Grams.</i> 0.14	<i>Grams.</i> 0.60	<i>Grams.</i> .....	<i>Calories.</i> 16
VEGETABLE FOOD.						
Honey, 133 grams, 7 cents (48) .....		.06		5.37		21
Vegetables: Tomatoes, 666 grams, 4 cents (32) .....		.30	.13	1.10	0.20	7
Fruits, fresh: Apples, Newtown Pippin, 6,682 grams, 22 cents (242a); bananas, 118 grams, 2 cents (212a); cantaloupe, 3,714 grams, 29 cents (228); grapes, Verdal, 7,825 grams, 69 cents (211a); grapes, Cornichon, 7,735 grams, 68 cents (207a); grapes, Tokay, 2,475 grams, 22 cents (205a); grapes, Muscat, 3,374 grams, 30 cents (202a); scarlet haws, 2,471 grams (201a); pears, 2,802 grams, 19 cents (51a); pomegranates, 62 grams, 1 cent (33); persimmons, 2,098 grams, 46 cents (52a); oranges, 57 grams, 1 cent (238a); strawberries, 808 grams, 12 cents (39); watermelon, 3,955 grams, 13 cents (200) .....	17	15.23	5.79	225.14	18.23	976
Fruits, dried: Figs, 1,309 grams, 20 cents (35) .....	1	2.81	.46	40.91	5.56	180
Olive oil, 207 grams, 23 cents (49) .....	1		10.35			91
Nuts: Almonds, 496 grams, 16 cents (249); peanut butter, 1,006 grams, 44 cents (44) .....	3	19.02	36.86	13.22	.64	422
Total vegetable food .....	22	37.42	53.59	285.74	24.63	1,697
Total food .....	23	40.34	53.73	286.34	24.63	1,713

The commonly accepted dietary standard for a man at sedentary work calls for 92 grams of protein and 2,700 calories. From the table it appears that the protein in this dietary was less than one-half and the energy about two-thirds, respectively, of these amounts. It is true that the subject's weight was small; but even if the data are calculated to the basis of a man weighing 150 pounds the results will still be far below the standard.

It is interesting in this connection to compare this dietary with those followed by the same subject in 11 four-day digestion experiments, in which the diet was made up of several fruits and nuts alone or in combination. (Reported on pp. 35-43 and summarized in Table 27.) In the dietary studies the subject ate at the dictates of his appetite, but in the digestion experiments the kind and amount of food eaten was determined upon beforehand in every case. In one experiment the diet consisted of grapes only, and furnished 13.75 grams protein and 1,096 calories per day. Such a diet soon becomes unpalatable, no matter how appetizing the food may be under ordinary circumstances. It must also be remembered that though the bulk consumed was large, the amount of nutriment supplied was very small, owing to the high percentage of water in the grapes, and the food is therefore not strictly comparable with a more varied diet. In all the other digestion experiments the diet was made up of fruits and nuts and furnished more protein and energy than the food eaten during the dietary study, the average of all the tests, including that with the grape diet, being



58.7 grams protein and 3,075 calories per day. In other words, the diet of the digestion experiment when the food was limited in kind was more generous than that of the dietary study when the food was selected at will. That the subject was benefited by the more abundant diet is indicated by the gain in weight of several pounds which he made during the time covered by the digestion experiments.

### DIETARY STUDY OF A VEGETARIAN (NO. 356.)

The study commenced November 8, 1901, and ended December 1, lasting twenty-four days. The total number of meals taken was forty-eight, or two per day. The subject was a man 64 years old, height 5 feet 7 inches, weighing 136 pounds.

He stated that he had been a strict vegetarian for eleven years and that previous to that time it had been his custom to eat but little meat. He also said that he had led an active life, working hard with brain and muscle.

In Table 6 are given the results of this study.

TABLE 6.—Weights and cost of food and nutrients consumed in dietary study No 356.

Kinds, amounts, and cost of different food materials.	Cost and composition of food per person per day.					
	Cost.	Protein.	Fat.	Sugar, starch, etc.	Crude fiber.	Fuel value.
VEGETABLE FOOD.						
	<i>Cents.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
Cereals: Granose, 2,155 grams, 48 cents (243); gluten flour, 454 grams, 15 cents (17); rice, flaked, 1,673 grams, 26 cents (245).....	3.71	21.27	1.47	131.90	2.11	645
Honey, 1,985 grams, 109 cents (48).....	4.54	.69	.....	66.81	.....	259
Vegetables: Baked beans, 1,021 grams, 11 cents (26)	.46	3.28	1.79	9.70	.....	64
Fruits, fresh: Apples, Bellflower, 5,585 grams, 18 cents (209a); bananas, 2,722 grams, 42 cents (212a); grapes, Verdal, 3,317 grams, 29 cents (211a); raspberries, 397 grams, 6 cents (40).....	4.00	3.36	2.06	48.60	3.08	214
Fruits, dried: Dates, 425 grams, 9 cents (37); figs, 28 grams, 1 cent (35); prunes, 794 grams, 18 cents (256a); raisins, 255 grams, 6 cents (257a) ..	1.42	1.70	.29	34.32	1.01	135
Nuts: Almonds, 907 grams, 30 cents (249); Brazil nuts, 1,361 grams, 45 cents (254); pine nuts, 198 grams, 3 cents (252); walnuts, 907 grams, 30 cents (223a).....	4.50	23.19	71.28	10.51	3.78	726
Total vegetable food.....	18.63	53.49	76.89	301.84	9.98	2,043

The table shows that this dietary contains about one-third more protein and nearly 12 per cent more energy than were noted for the previous one. The corresponding figures for a man weighing 150 pounds would be 59 grams protein and 2,444 calories.

The food eaten during this test, there is every reason to believe, represents very well the normal diet of this subject, who throughout the whole experimental period (October, 1901, to April, 1902) remained in excellent health and strength. It thus seems that this man could maintain his health when the daily diet furnished only 50 to 60 grams of protein, or about 60 per cent of the amount called for by the commonly accepted standard for a man at sedentary work.

The discussion of the preceding dietary showed that more protein and energy were furnished by the restricted daily diet during the digestion experiments than by the food consumed by the same subject during the period of the dietary study when he ate food chosen at will. As may be seen by a reference to Table 46, page 61, like conditions do not obtain for the subject of the present study. On an average the daily food eaten during the 16 digestion experiments furnished 44.01 grams protein and 1,831 calories. In other words, when the subject selected his daily food at will he ate somewhat more than was the case when his diet was fixed upon for experimental purposes.

#### DIETARY STUDY OF A BOY (NO. 357).

The study continued for twenty-one days in March, 1902. The subject was the same boy as in dietary study No. 331, previously reported,<sup>a</sup> and was now 10 years old. He weighed 58 pounds at the beginning and at the close of the study.

The number of meals eaten was forty-two, equivalent to one boy for twenty-one days or one man for thirteen days.

The details of the study are shown in Table 7.

TABLE 7.—*Weights and cost of food and nutrients consumed in dietary study No. 357.*

Kinds, amounts, and cost of different food materials.	Cost and composition of food per person per day.					
	Cost.	Protein.	Fat.	Sugar, starch, etc.	Crude Fiber.	Fuel value.
<b>ANIMAL FOOD.</b>						
Milk, 4,763 grams, 21 cents (9) .....	<i>Cents.</i> 1	<i>Grams.</i> 7.49	<i>Grams.</i> 9.07	<i>Grams.</i> 11.34	<i>Grams.</i> .....	<i>Calories.</i> 155
Eggs, 57 grams, 2 cents (12) .....	.....	.38	.32	.....	.....	4
Total animal food .....	1	7.87	9.39	11.34	.....	159
<b>VEGETABLE FOOD.</b>						
Cereals: Bread, corn, 595 grams, 7 cents (13); crackers, graham, 227 grams, 5 cents (16); fruit-nuts, 312 grams, 17 cents (247); gluten flour, 794 grams, 26 cents (17); granose, 340 grams, 8 cents (243); malted tablets, 369 grams, 20 cents (259) ..	4	15.44	4.47	82.15	.94	439
Honey, 16 grams, 1 cent (48) .....	.....	.....	.....	.62	.....	2
Vegetables: Cauliflower, 312 grams, 2 cents (29) ..	.....	.27	.07	.70	.....	4
Fruits, fresh: Apples, Permain, 13,920 grams, 46 cents, (229a); apples, Pippin, 6,946 grams, 23 cents (242a); oranges, 7,626 grams, 101 cents (238a) ..	8	7.22	1.70	129.36	8.48	535
Fruits, dried: Figs, 482 grams, 7 cents (35) .....	.....	.99	.16	14.34	1.95	63
Nuts: Almonds, 539 grams, 18 cents (250); peanuts, 312 grams, 5 cents (255); pecans, 794 grams, 26 cents (233); walnuts, 113 grams, 4 cents (223) ..	3	16.63	51.51	8.19	2.02	524
Olive oil, 8 grams (49) .....	.....	.....	.38	.....	.....	3
Total vegetable food .....	15	40.55	58.28	235.36	12.39	1,570
Total food .....	16	48.42	67.68	246.70	13.39	1,729

<sup>a</sup>U. S. Dept. Agr., Office of the Experiment Stations Bul. 107.

The tentative standard for a boy 10 years old calls for 65 grams protein and 1,750 calories, and it will be seen that the daily diet (48 grams protein and 1,558 calories) is far below it. It is, however, of more than passing interest to note that the present diet furnishes much more protein and energy than did that of the study previously reported,<sup>a</sup> which was made in the summer of 1900, which contained but 27 grams protein and 1,255 calories per day. It is true that at the time of the present investigation the boy was somewhat older and consequently would normally require more protein and energy, but the increase is about 65 per cent for the protein and 25 per cent for the energy, which is much greater than the difference in age calls for. The later diet was richer, presumably because it was more varied in character. In the previous study it was strictly fruitarian, while in the present case about 16 per cent of the protein and 10 per cent of the energy were of animal origin, and 32 per cent of the protein and 8 per cent of the energy were derived from cereals. In other words, in the present case the fruit and nuts supplied only about 56 per cent of the protein and 62 per cent of the energy of the diet.

The use of the mixed diet was accounted for by the fact that for certain family reasons it was expected that the boy would in future live with relatives in the East, and as they were not fruitarians, or even vegetarians, it was deemed advisable to have the dietary include some of the more common foods in order to accustom him to their use.

#### DIETARY STUDY OF A GIRL FRUITARIAN (NO. 358).

The study commenced February 28, 1902, and ended March 20, lasting twenty-one days. The subject was a girl (sister of the subject of study No. 357) 8 years old, and weighed 37 pounds at the beginning and end of the test.

Studies were made of the dietary of this subject during the summer of 1900, and again in the spring of 1901, both of which have been reported.<sup>a</sup> As was then stated, her light weight and small measurements were presumably due in part at least to heredity, as her mother and grandmother were very small women.

The total number of meals taken was forty-two, equivalent to one girl for twenty-one days or one man for eleven days.

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<sup>a</sup> U. S. Dept. Agr., Office of Experiment Stations Bul. 107.

The table following gives the details of the study:

TABLE 8.—*Weights and cost of food and nutrients consumed in dietary study No. 358.*

Kinds, amounts, and cost of different food materials.	Cost and composition of food per person per day.					
	Cost.	Protein.	Fat.	Sugar, starch, etc.	Crude fiber.	Fuel value.
VEGETABLE FOOD.						
	<i>Cents.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
Cereals: Gluten flour, 113 grams, 4 cents (17); fruit nuts, 113 grams, 6 cents (247); malt tablets, 340 grams, 19 cents (259) .....	1.38	2.52	0.51	21.08	0.19	101
Honey, 8 grams (48) .....				.31		1
Vegetables: Cauliflower, 454 grams, 2½ cents (29); lettuce, 57 grams, 1 cent (30) .....	.17	.42	.12	1.02		7
Fruits, fresh: Apples, Permain, 10,238 grams, 34 cents (229a); apples, Pippin, 5,103 grams, 17 cents (242a); olives, 142 grams, 3 cents (240); oranges, 10,408 grams, 138 cents (238a) .....	9.14	7.63	3.10	113.69	7.45	488
Fruits, dried: Raisins, 28 grams, 1 cent (257) .....		.06	.01	.83	.01	3
Olive oil, 104 grams, 11 cents (49) .....	.52		4.95			43
Nuts: Almonds, 907 grams, 30 cents (250); pecans, 1,191 grams, 39 cents (234); hickory nuts, 85 grams, 2 cents (43); pignolias, 113 grams, 6 cents (252); nut and fig bromose, 340 grams, 19 cents (258) .....	4.57	21.64	72.99	18.13	3.02	760
Total vegetable food .....	15.78	32.27	81.68	155.06	10.67	1,403

Some cereals and commercial articles of vegetable origin were eaten in addition to vegetables, fruit, nuts, olive oil, and honey. Cereals supplied about 8 per cent of the protein and between 5 and 6 per cent of the energy of the diet. Such a dietary is not strictly fruitarian, but as fruit and nuts, chiefly the latter, furnished about 92 per cent of the protein and nearly 95 per cent of the energy, it was thought best to classify it under that head.

Notwithstanding the small amount of protein in this dietary the subject seemed, as she did at the time of the studies made the previous year, to be perfectly healthy but very small for her age.

#### DIETARY STUDY OF A FRUITARIAN (NO. 359).

The study began March 1, 1902, and continued for twenty-one days. The subject, a woman, was the same as in dietary study No. 328 previously reported,<sup>a</sup> 34 years old, height 5 feet, weighing 93.5 pounds at the beginning and end of the study. The number of meals taken was forty-two, equivalent to one woman for twenty-one days or one man for fifteen days.

Table 11 shows in detail the results of this study.

<sup>a</sup> U. S. Dept. Agr., Office of Experiment Stations Bul. 107.



TABLE 9.—*Weights and cost of food and nutrients consumed in dietary study No. 359.*

Kinds, amounts, and cost of different food materials.	Cost and composition of food per person per day.					
	Cost.	Protein.	Fat.	Sugar, starch, etc.	Crude fiber.	Fuel value.
VEGETABLE FOOD.	<i>Cents.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
Cereals: Gluten flour, 198 grams, 7 cents (17); Granose, 57 grams, 1 cent (243); fruit nuts, 57 grams, 3 cents (247); malt tablets, 85 grams, 5 cents (259) .....	0.76	2.73	0.45	13.28	0.20	70
Honey, 12 grams, 1 cent (48) .....	.19	.58	.16	.45	.....	2
Vegetables: Cauliflower, 680 grams, 4 cents (29) .....				1.53	.....	9
Fruits, fresh: Apples, Permain, 11,624 grams, 38 cents (229a); apples, Pippin, 5,812 grams, 19 cents (242a); oranges, 8,907 grams, 118 cents (238a) .....	8.33	7.17	1.58	117.85	7.62	489
Fruits, dried: Apricots, 85 grams, 2 cents (34); raisins, 57 grams, 1 cent (257) .....	.14	.31	.06	4.23	.02	16
Olive oil, 140 grams, 16 cents (49) .....	.76	.....	6.67	.....	.....	58
Nuts: Almonds, 1,332 grams, 44 cents (250); filberts, 312 grams, 10 cents (42); pecans, 28 grams, 1 cent (233); pignolias, 1,049 grams, 58 cents (252); hickory, 85 grams, 2 cents (43); nut and fig bromose, 57 grams, 3 cents (258) .....	5.62	31.69	72.18	19.49	1.95	788
Total vegetable food .....	15.80	42.48	81.10	156.83	9.79	1,432

In the study with this subject previously reported the diet furnished 33 grams protein and 1,300 calories per day. The above table shows a daily consumption of almost 25 per cent more protein and about 7 per cent more energy. In the present study cereals formed part of the diet, supplying 2.7 grams protein and 13.5 grams carbohydrates, whereas during the former test the diet with the exceptions of a little olive oil and honey consisted exclusively of fruit and nuts.

The tentative standard for a woman at light work calls for 90 grams of protein and 2,250 calories, amounts which are far in excess of those furnished by the present diet.

#### DIETARY STUDY OF A STUDENT (NO. 360).

This study and the two succeeding ones, Nos. 361 and 362 beyond, form part of an investigation undertaken for the purpose of ascertaining the value of an exclusive fruitarian diet for a healthy, active young man accustomed to the conventional mixed diet.

The subject selected was a vigorous, healthy university student, 22 years old, conscientious in his studies and prominent in athletics.

The investigation was divided as follows: (1) A study of seven days' duration (No. 360), during which time he ate his usual mixed diet; (2) a study of nine days' duration (No. 361), during which time a large proportion of fruit was used as a substitute for part of the meat, eggs, and cereals of the usual daily fare; and (3) a study of eight days' duration (No. 362), during which time, with the exception of 10 grams per day of cane sugar, the diet was composed exclusively of fruit and nuts. Following the above two metabolism experiments on a strictly fruitarian diet were carried on, for the details of which see pages 67, 68.



Dietary study No. 360 continued for seven days in March, 1902, the total number of meals taken being twenty-one, or three per day.

The subject weighed 169 pounds at the beginning and 169.5 pounds at the end of the test. It was not practicable to weigh him without clothing, but the same clothes were worn and the same scales used for both weighings.

TABLE 10.—*Weights and cost of food and nutrients consumed in dietary study No. 360.*

Kinds, amounts, and cost of different food materials.	Cost and composition of food per person per day.				
	Cost.	Protein.	Fat.	Sugar, starch, etc.	Fuel value.
<b>ANIMAL FOOD.</b>					
	<i>Cents.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
Beef: Medium fat, 992 grams, 44 cents (1).....	6.28	25.95	25.51	.....	341
Hamburg steak, 312 grams, 11 cents (3).....	1.57	8.83	6.06	.....	92
Beef heart, 113 grams, 3 cents (4).....	.43	2.58	3.29	.....	41
Beef soup, 454 grams, 5 cents (5).....	.71	2.85	.26	0.71	17
Pork, ham, 227 grams, 11 cents (6).....	1.57	5.22	12.58	.....	135
Fish: Striped bass, 113 grams, 5 cents (7); lobster, 85 grams, 3 cents (8).....	1.14	4.95	.67	.05	27
Eggs, 66 grams, 2 cents (12).....	.28	1.32	1.13	.....	16
Butter, 198 grams, 11 cents (10).....	1.57	.28	24.04	.....	212
Milk, 563 grams, 3 cents (9).....	.43	2.65	3.21	4.02	55
Total animal food.....	13.98	54.63	76.75	4.78	936
<b>VEGETABLE FOOD.</b>					
Cereals: Oatmeal, 1,219 grams, 27 cents (18); bread, 1,985 grams, 22 cents (14); cake, 340 grams, 8 cents (15).....	8.14	58	9.78	217.79	1,091
Pie and puddings: Apple pie, 85 grams, 2 cents (19); custard pie, 85 grams, 2 cents (20); tapioca pudding, 85 grams, 3 cents (21); rice custard, 85 grams, 3 cents (22); gelatin, 2 grams, 1 cent (23).....	1.57	.01	2.90	15.60	96
Sugar and starch: Sugar, 321 grams, 4 cents (46); sago, 9 grams, 1 cent (47).....	.71	.11	.....	46.86	181
Vegetables: Beans, 170 grams, 2 cents (25); potatoes, 1,332 grams, 4 cents (31); cauliflower, 57 grams (29).....	.86	7.38	5.90	41.32	237
Fruits, fresh: Apples, 198 grams, 1 cent (24); oranges, 193 grams, 3 cents (238); bananas, 85 grams, 1 cent (212).....	.71	.72	.12	10.23	40
Total vegetable food.....	11.99	39.80	18.70	331.80	1,645
Total food.....	25.97	94.43	95.45	336.58	2,581

The protein and energy furnished by the present diet are considerably below the tentative standard for a man with light to moderate muscular work, namely, 112 grams protein and 3,050 calories, but since the subject had the opportunity to eat all he wanted and gained in weight it would seem that the 94 grams protein and the 2,600 calories per day were sufficient for his bodily needs.

#### DIETARY STUDY NO. 361.

The study commenced March 26, 1902, and ended April 3, lasting nine days. The total number of meals eaten was twenty-seven, or three per day. The subject weighed 168 pounds at the beginning and 170 pounds at the close. As previously stated, the proportion of fruits and nuts eaten was large, the purpose being to thus accustom the subject to such foods and avoid a sudden change from ordinary fare to a fruitarian diet.

Table 11 shows in detail the results of this test.

TABLE 11.—*Weights and cost of food and nutrients consumed in dietary study No. 361.*

Kinds, amounts, and cost of different food materials.	Cost and composition of food per person per day.					
	Cost.	Protein.	Fat.	Sugar, starch, etc.	Crude fiber.	Fuel value.
ANIMAL FOOD.						
	<i>Cents.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
Beef: Medium fat, 1,418 grams, 63 cents (1); corned, 85 grams, 2 cents (2); beef soup, 425 grams, 5 cents (5) .....	7.78	36.40	34.89	0.58	.....	473
Butter, 142 grams, 8 cents (10) .....	.89	.18	15.10	.....	.....	133
Total animal food .....	8.67	36.58	49.99	.58	.....	606
VEGETABLE FOOD.						
Cereals: Bread, 1,276 grams, 14 cents (14); cake, cup, 680 grams, 15 cents (15) .....	3.22	17.29	10.20	150.74	0.25	773
Pie, pudding, etc.: Rice custard, 255 grams, 8 cents (22); tapioca pudding, 85 grams, 3 cents (21); gelatin, 2 grams, 1 cent (23) .....	1.33	1.84	1.81	13.01	.....	76
Cane sugar, 307 grams, 4 cents (46) .....	.45	.....	.....	38.38	.....	148
Vegetables: Potatoes, 1,162 grams, 4 cents (31); cabbage, 85 grams, 1 cent (27); artichokes, 113 grams, 2 cents (24) .....	.78	4.31	4.42	28.81	.....	165
Fresh fruits: Apples, 170 grams, 1 cent (242); bananas, 1,247 grams, 19 cents (212); oranges, 1,724 grams, 22 cents (238) .....	4.67	5.34	.79	59.61	.....	259
Dried fruits: Raisins, 680 grams, 15 cents (257); apricots, 907 grams, 6 cents (34) .....	2.33	9.20	1.65	124.60	.....	494
Cooked and canned fruits: Apple sauce, 255 grams, 3 cents (41); peaches, canned, 113 grams, 4 cents (228) .....	7.78	.14	.25	13.63	.....	52
Nuts: Walnuts, 397 grams, 13 cents (223) .....	1.45	12.20	31.22	3.28	.....	314
Total vegetable food .....	22.01	50.32	50.34	432.06	.25	2,261
Total food .....	30.68	86.90	100.33	432.64	.25	2,867

It will be seen that the present dietary furnishes 7 grams less protein and 300 calories more energy than study No. 360 with the same subject. It is interesting to note that while in the previous study fruit furnished only 0.72 gram protein, in the present study it supplies 14.7 grams, and nuts 12.2 grams, protein per day. The total animal protein in study No. 360 was 54.6 grams, and in the present study only 36.6 grams per day.

In this period of change from the ordinary mixed diet to one containing a considerable quantity of fruit and nuts, the subject stated that on the fourth and fifth days of the study, in addition to his regular college duties, a large amount of extra work was performed, involving mental strain and loss of sleep. Notwithstanding this extra demand on his vitality, his physical condition so far as could be judged was unchanged and his weight increased two pounds. The subject stated that, having made the comparison, he preferred a fruitarian breakfast to any other. In general he relished the diet consisting almost exclusively of fruit and nuts.

#### DIETARY STUDY NO. 362.

This study began April 9 and continued for eight days. The total number of meals eaten was twenty-four, or three per day. During the six days' interval between this and dietary study No. 361 the sub-

ject continued to use a large proportion of fruit and nuts in the diet. With the exception of about 10 grams of cane sugar per day, the diet in the present study consisted entirely of fruit and nuts. The subject weighed at the commencement of the experimental period 170 pounds, and 168 pounds at its close.

The details of the study follow:

TABLE 12.—*Weights and cost of food and nutrients consumed in dietary study No. 362.*

Kinds, amounts, and costs of different food materials.	Cost and composition of food per person per day.				
	Cost.	Protein.	Fat.	Sugar, starch, etc.	Fuel value.
VEGETABLE FOOD.					
	<i>Cents.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
Fresh fruits: Bananas, 4,196 grams, 65 cents (212); oranges, 6,294 gram, 83 cents (238).....	18.50	18.30	2.68	195.95	789
Dried fruits: Dates, 737 grams, 16 cents (36); figs, 425 grams, 14 cents (35); raisins, 454 grams, 10 cents (257).....	5.00	7.54	.99	126.29	488
Canned fruits: Peaches, 340 grams, 11 cents (228) ..	1.38	.23	.....	5.34	20
Nuts: Almonds, 567 grams, 19 cents (249); peanuts, 85 grams, 1 cent (255); walnuts, 1,418 grams, 47 cents (223).....	8.37	59.28	155.03	28.11	1,598
Cane: Sugar, 85 grams, 1 cent (46).....	.12	.....	.....	10.63	41
Total vegetable food .....	33.37	85.35	158.70	366.32	2,936

There were no restrictions regarding the kind and amount of fruit or nuts to be used in this dietary. On the other hand, the subject was instructed to eat all he wished of any fruit and nuts which he desired. Bananas and oranges, dates and raisins, almonds and walnuts were his favorite foods, though some other sorts of fruit and nuts were eaten. The protein in the diet thus selected is almost identical in amount with that furnished by the diet in study No. 361, though less by 9 grams than in study No. 360, while the fuel value is higher in this test than in either of the other two. In all these tests the protein is below the requirement of the tentative American standard for a man at moderately active work. In the present test, however, the energy is equal to that called for by the standard. It will be seen by noting the data in Tables 50 and 51, experiments Nos. 417 and 418, that the unrestricted fruitarian diet selected by the subject himself, which furnished nearly as much protein and rather more energy than was consumed by him when using his ordinary mixed diet, was superior as regards both protein and energy to the restricted diets of bananas, dates, and walnuts, and bananas, oranges, and walnuts, used in digestion experiments made with the same subject.

As noted above, there was a loss of 2 pounds, but the initial weight was above the subject's normal, and during the test he was under unusual strain, both physical and mental, particularly on three days (April 11-13). It seems, therefore, that it is not just to ascribe the loss in weight during the experiment entirely to the fruit and nut diet.

As the loss is not great, and indeed quite within the range which is observed in the weight of persons under normal conditions during a period of equal duration, it would seem fairer to give the diet much credit for being able to carry an active, energetic, healthy man through a period of unusual strain, both physical and mental, attendant upon some special work in addition to his regular college duties.

### DIETARY STUDY OF A FRUITARIAN (NO. 363.)

The study commenced April 23, 1902, and continued for ten days. The subject was a man who had been experimenting with the fruitarian diet for several years. He was 25 years old and did not gain or lose weight (without clothes), the weights for the different days, with the exception of the third and ninth days, when no weight was recorded, being 151.1, 153, 154.3, 153.1, 148.1, 150.3, 150.8, and 151.1 pounds. On the fifth day the subject ate no supper and on the ninth day no lunch. On other days three meals were eaten. The total number of meals taken was therefore 28, which in this case was assumed to be equivalent to one man for ten days.

The details of the study are shown in Table 13.

TABLE 13.—*Weights and cost of food and nutrients consumed in dietary study No. 363.*

Kinds, amounts, and cost of different food materials.	Cost and composition of food per person per day.					
	Cost.	Protein.	Fat.	Sugar, starch, etc.	Crude fiber.	Fuel value.
VEGETABLE FOOD.						
	<i>Cents.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
Fresh fruits: Apples, Pippin, 7,068 grams, 23 cents (242a); bananas, 5,498 grams, 85 cents (212a); oranges, navel, 13,440 grams, 178 cents (238a); olives, 107 grams, 2 cents (240a).....	28.8	22.30	5.47	270.67	31.81	1,210
Dried fruits: Dates, 1,799 grams, 40 cents (36); figs, 2,518 grams, 83 cents (35).....	12.3	15.90	2.31	256.32	25.48	1,087
Whisky, 60 grams, 7 cents (50).....	.7			5.10		20
Nuts: Almonds, 565 grams, 19 cents (249); coconuts, 357 grams, 4 cents (231); walnuts, 733 grams, 24 cents (223).....	4.7	29.66	95.00	17.47	7.43	984
Cocanut milk, 124 grams, 5 cents (45) .....	.5	.05	.19	.57		4
Total vegetable food.....	47.0	67.91	102.97	550.13	64.72	3,305

This diet furnished practically 68 grams protein per day, or about two-thirds the amount called for by the commonly accepted standards for a man at light muscular work. The fuel value, however, slightly exceeded the limits of the standard.

Notwithstanding the variety of foods in this diet which were selected by the subject, it did not furnish as much protein as did the diet limited by the experimental conditions and consisting of bananas, oranges, and almonds, used in a digestion experiment (No. 416, Table 49) with the same subject.



## DISCUSSION OF THE DIETARIES.

In the study of a fruitarian diet previously published<sup>a</sup> it was noted that the foods used were almost exclusively fruit and nuts, the latter being the main sources of protein and fat, while the fruit furnished the bulk of the carbohydrates, consisting chiefly of the different sorts of sugar, with considerable crude fiber and a small amount of starch. All the food was eaten raw. The cost of the diet varied from 17 cents to 27.5 cents per person per day, and was on the average 20.7 cents. Both the protein and the energy in every case were far below the limits called for by the tentative American standards for persons performing a like amount of muscular work. No general conclusions were drawn, as the data did not seem sufficient to warrant them. An examination of the data recorded above will show that the present studies agree essentially with those previously reported.

In discussing the general question of a fruitarian diet it is of interest, for purposes of comparison, to quote the results obtained by other investigators in studies of a vegetarian diet with subjects whose daily fare included a considerable amount of fruit and nuts.

Voit<sup>b</sup> studied the dietary of a vegetarian 28 years old, height 5 feet 5 inches, weighing 125 pounds, whose average daily diet consisted of 131 grams pumpnickel, 438 grams graham bread, 777 grams apples, 114 grams dried figs, 247 grams dates, 66 grams oranges, 8 grams olives, and 21 grams olive oil.

Ten years later Rumpf and Schumm<sup>c</sup> reported a metabolism experiment with a vegetarian 19 years old, weighing 138 pounds, whose daily consumption of food was as follows: 330 grams graham bread, 1,160 grams apples, 260 grams dates, 140 grams Quaker Oats, 100 grams rice, 75 grams sugar, and 30 grams nuts.

Albu,<sup>d</sup> in 1901, made a digestion experiment lasting five days, with a vegetarian, a woman, 42 years old, whose weight was 83 pounds and height 4 feet 3 inches. Her average daily diet included 120 grams graham bread, 400 grams apples, 400 grams plums, 200 grams grapes, 64 grams nuts (without shells), 170 grams dates, and 100 grams lettuce. The same author reports a twelve-day dietary study of one of the leaders of the vegetarian movement in Germany, a man 48 years old, height 5 feet 8 inches, weighing (with clothes) 153 pounds. The average daily diet consisted of 1,000 grams potatoes, 166 grams hazelnuts, 12.5 grams peanuts, 83 grams plums, 71 grams sugar, 93 grams raisins, 354 grams apples, 63 grams oranges, and 50 grams olive oil.

In Table 14 are given the results of all the dietary studies made with

<sup>a</sup> U. S. Dept. Agr., Office of Experiment Stations Bul. 107.

<sup>b</sup> Ztschr. Biol., 25 (1889), p. 232.

<sup>c</sup> Ztschr. Biol., 39 (1899), p. 153.

<sup>d</sup> Ztschr. Klin. Med., 43 (1901), p. 75.



fruitarians at the University of California, and, for purpose of comparison, the tabulated results of the German dietaries referred to above, the average results of a number of American dietaries, and the tentative American standards for a man at sedentary and at moderately active work and for a woman at light work. In making the calculations it was assumed that a woman would consume seven-tenths as much as a man at moderate muscular work. The usual factor for a woman is 0.8, but in the present instance the subject was very small of stature, below the average in height and weight, and did only light housework. The factors used for the boy and girl were 0.6 and 0.5, respectively.

TABLE 14.—*Comparison of daily dietaries of fruitarians and vegetarians with commonly accepted standards.*

	Weight of subject.	Nature of dietary.	Cost.	Pro- tein.	Fat.	Car- bohy- drates.	Fuel value.	Nutri- tive ratio.
STUDIES WITH WOMEN AND CHILDREN, VALUES AS DETERMINED.	<i>Pounds.</i>		<i>Cents.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>	<i>1:</i>
Woman, 33 years old, diet- ary No. 328. <sup>a</sup>	90.0	Fruitarian....	23.7	33	59	150	1,300	8.6
Woman, 34 years old, diet- ary No. 359.	91.5	Vegetarian ...	15.8	43	81	167	1,430	8.0
Boy, 9 years old, dietary No. 331. <sup>a</sup>	45.0	Fruitarian....	19.9	27	56	152	1,255	10.3
Boy, 10 years old, dietary No. 357.	58.0	Mixed .....	16.0	48	68	260	1,730	7.6
Girl, 6 years old, dietary No. 332. <sup>a</sup>	33.0	Fruitarian....	17.0	24	58	134	1,190	11.1
Girl, 7 years old, dietary No. 333. <sup>a</sup>	35.0	.....do .....	27.5	40	72	134	1,385	7.4
Girl, 8 years old, dietary No. 358.	37.0	Vegetarian ...	15.7	32	82	165	1,403	10.9
Woman, 42 years old (Albu).	83.0	.....do .....	.....	34	36	227	1,399	9.1
Do .....	.....	.....do .....	.....	49	51	324	1,998	9.1
STUDIES WITH WOMEN AND CHILDREN, VALUES CAL- CULATED TO BASIS OF MAN AT MODERATE MUS- CULAR WORK.								
Woman, 33 years old, diet- ary No. 328. <sup>a</sup>	.....	Fruitarian....	33.9	47	84	214	1,850	8.6
Woman, 34 years old, diet- ary No. 359.	.....	Vegetarian ...	21.0	61	116	239	2,050	8.0
Boy, 9 years old, dietary No. 331. <sup>a</sup>	.....	Fruitarian....	39.8	54	112	304	2,510	10.4
Boy, 10 years old, dietary No. 357. <sup>b</sup>	.....	Mixed .....	27.0	80	113	433	2,880	7.6
Girl, 6 years old, dietary No. 332. <sup>a</sup>	.....	Fruitarian....	34.0	48	116	268	2,375	11.1
Girl, 7 years old, dietary No. 333. <sup>a</sup>	.....	.....do .....	55.0	80	144	268	2,770	7.4
Girl, 8 years old, dietary No. 358.	.....	Vegetarian ...	31.4	64	164	328	2,805	10.9
Woman, 42 years old (Albu).	.....	.....do .....	.....	41	43	272	1,679	.....
Do .....	.....	.....do .....	.....	59	61	390	2,398	.....
STUDIES WITH MEN.								
Man, 63 years old, dietary No. 355.	124.0	Fruitarian....	23.0	40	54	311	1,712	10.9
Man, 64 years old, dietary No. 356.	136.0	Vegetarian ...	18.1	54	77	312	2,044	9.0
Man, 22 years old, dietary No. 360. <sup>b</sup>	169.0	Mixed .....	26.0	94	96	337	2,582	6.9

<sup>a</sup>See U. S. Dept. Agr., Office of Experiment Stations Bul. 107, p. 18.

<sup>b</sup>Not included in average.

TABLE 14.—*Comparison of daily dietaries of fruitarians and vegetarians with commonly accepted standards—Continued.*

	Weight of subject.	Nature of dietary.	Cost.	Pro- tein.	Fat.	Car- bohy- drates.	Fuel value.	Nutri- tive ratio.
STUDIES WITH MEN—cont'd.	<i>Pounds.</i>		<i>Cents.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>	<i>1.</i>
Man, 22 years old, dietary No. 361. <sup>a</sup>	168.0	Mixed .....	30.7	87	100	433	2,870	7.6
Man, 22 years old, dietary No. 362.	170.0	Fruitarian....	33.4	85	159	366	2,937	8.5
Man, 25 years old, dietary No. 363.	151.0	.....do .....	47.0	68	103	615	3,305	12.3
Average .....				62	98	401	2,493	10.0
Man, 48 years old (Albu)...	153.0	Vegetarian .....		63	66	593	3,302	11.8
Man, 28 years old (Voit)...	125.0	.....do .....		54	22	573	2,775	11.6
Man, 19 years old (Rumpf and Schumm).	138.0	.....do .....		74	28	700	3,431	10.3
Average of 53 studies of well-to-do families in the United States.				103	138	436	3,500	7.3
DIETARY STANDARDS.								
Man at sedentary or woman with moderately active work (Atwater).		Mixed .....		100			2,700	6.1
Man with light to moderate muscular work (At- water).		.....do .....		112			3,050	6.1
Man with moderate mus- cular work (Voit).		.....do .....		118	56	500	3,055	5.3
Man with moderately active muscular work (At- water).		.....do .....		125			3,400	6.2
Woman with light to moderate muscular work, or man without muscular exercise (At- water).		.....do .....		90			2,450	6.1

<sup>a</sup>Not included in average.

It will be seen from the table that the results of the two investigations at the University of California (1901 and 1902) correspond very closely and also agree in the main with the findings of the German investigators quoted in showing a uniformly small amount of protein in the daily diet. This appears to obtain whether the diet is exclusively or partly fruitarian.

It will be noted that the nutritive ratios of dietaries Nos. 359 and 357 are narrower than in previous dietary studies with the same subjects. This and the increased fuel value and the decreased cost of the dietaries also observed are presumably partly due to the use of cereals in the latter studies. A comparison of dietaries Nos. 332, 333, and 358 shows that at less cost the latter furnishes more protein and energy than No. 332. Dietary No. 333 furnishes more protein with nearly the same fuel value as stated for No. 358, but the daily cost of the former (27.5 cents) greatly exceeds that of the latter (15.7 cents).

The tabulated results of the fruitarian and vegetarian dietaries for men show that the minimum quantity of protein (40 grams) and energy (1,712 calories) per day are found in dietary No. 355. It is of more than passing interest to observe that the maximum daily protein content for the fruitarian dietaries (85 grams) is not reported with a

fruitarian or even with a vegetarian, but with a student accustomed all his life to a mixed diet, who followed the fruit and nut diet for the first time during the period covered by study No. 362. It appears from the table that, notwithstanding the high price of meat, the cost of the mixed dietary No. 360 (26 cents per day) is less than that of either of the two succeeding studies made with the same subject. The fuel value, however, is greatest in study No. 362, with a strictly fruitarian diet, the protein being but 9 grams less than in study No. 360.

The average value for the daily protein (62 grams) of the American vegetarian and fruitarian dietary studies made with men is practically identical with the corresponding average for German experiments. There is not, however, such a close agreement in the case of energy, for in the German studies the minimum, 2,775 calories, reported by Voit exceeds by 10 per cent the average of the American studies. Finally, it should be noted that as regards protein all the dietaries here recorded are decidedly deficient as compared with the commonly accepted American dietary standard for men at similar work. The question how much protein is necessary daily for a man in order that he shall maintain his nitrogen balance at the most satisfactory protein level is an exceedingly important one.

The fuel value of the dietaries here reported seems to approach much nearer the accepted standard than the protein, and in one case (study No. 363) is slightly in excess of it. The cost of the daily diets varies from 18.1 cents in study No. 356 to 46.5 cents in study No. 363. It would thus seem that for a man at moderate work a strictly fruitarian diet would not be economical. At the same time it seems certain that a vegetarian diet fulfilling all the requirements of our tentative standards could be arranged which would cost no more than the average conventional diet and might in many cases cost less. The fruitarian diet possesses an advantage in that there is practically no waste. In the case of nuts and fruit of the best quality the only refuse is the uneatable portion, such as shells of nuts, stems of fruit, etc., and in the case of prepared cereals even this does not obtain, as the waste (hulls, etc.) is supposed to have been removed before they have been marketed.

It appears to the writer from his experience that one serious and very common fault with the vegetarians is their ignorance of the nutritive value of the different fruits, nuts, and vegetable foods in general, which accounts for the selection of foods furnishing at a fairly high price much less nutritive material than could be furnished for the same sum or less by other vegetable foods or by more reasonable combinations.

## DIGESTION EXPERIMENTS.

The object of conducting the experiments here recorded was to gather data relative to the digestibility of fruit and nuts, not only for the purpose of ascertaining the quantities of nutriment utilized by the vegetarian and fruitarian, which is of course of great physiological interest, but also in order to learn whether fruit and nuts should be considered as sources of nourishment in any considerable degree and not merely as luxuries or as articles of supposed hygienic or medical value.

Thirty-one digestion experiments, which included also determinations of the nitrogen balance, were made with four different men. Two of them, W. S. M. and C. P. H., subjects of dietary studies Nos. 355 and 356, respectively, were upward of 60 years old. They had been, as already noted, accustomed to the fruitarian and vegetarian diet for many years. Subject C. P. H. was in excellent health throughout the entire experimental period. Subject W. S. M. complained at different times of numbness in the feet and fingers, which had been troubling him for several years.<sup>a</sup>

The other two men were university students in good health. J. E. R., subject of dietaries Nos. 360, 361, and 362, was accustomed to a mixed diet and was placed on the fruitarian diet for purposes of comparison. A. V., the subject of dietary No. 363, had been experimenting with the fruitarian diet for several years.

The usual method was followed in conducting these experiments, which, with two exceptions, lasted four days each. All the food eaten and the resulting urine and feces were carefully weighed and analyzed.

The energy of the urine was computed by assuming that for every gram of protein in the digested material there would be 1.25 calories of energy lost in the organic matter of the urine.<sup>b</sup> The separation of the feces was made by means of charcoal, taken either in the form of compressed tablets or in gelatin capsules. It was somewhat difficult at times to make an accurate separation, but in the majority of the tests the line of demarcation between the feces colored by the charcoal and those not so marked was clear and distinct. In nineteen of the experiments the feces were examined for the so-called metabolic nitrogen.

It was planned to make tests with single fruits and then combine them in succession with the different nuts ordinarily used, as it was thought that in this way the digestion coefficients of the different nuts alone could be obtained by making the usual calculations and that their comparative digestibility would also be shown. In all, ten

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<sup>a</sup> Six months after the conclusion of the experiment the subject became ill, and the physician diagnosed the case as locomotor ataxia, which later terminated fatally.

<sup>b</sup> U. S. Dept. Agr., Office of Experiment Stations Bul. 53, p. 27; Bul. 121, p. 21.



different varieties of fruit and six of nuts were experimented with. The subjects ate ad libitum of the fruits and nuts decided upon for the experiment. In some cases the diet of a single fruit or of a fruit with nuts proved so unpalatable that it was deemed best to supply small amounts of olive oil, tomatoes, or other materials in addition, in a number of cases these articles being taken simply as relishes. When this was done the diet was regarded as palatable. It is to be regretted, however, that owing to the difficulty of following such a diet for any length of time only two experiments were made with a single fruit.

### EXPERIMENTS WITH W. S. M.

The experiments with each of the subjects are grouped together. Those with W. S. M. follow:

#### DIGESTION EXPERIMENT NO. 388.

*Kind of food.*—Grapes, with small quantities of olive oil, tomatoes, and olives.

*Subject.*—W. S. M.

*Weight (with clothing).*—At the beginning of the experiment 56.3 kilograms (124 pounds) and at the close 55.3 kilograms (122 pounds).

*Duration.*—Four days, with twelve meals, beginning with breakfast November 19, 1901.

TABLE 15.—Results of digestion experiment No. 388.

Sam- ple No.	Kind of food.	Weight of ma- terial.	Total organic matter.	Nitro- gen.	Pro- tein.	Fat.	Carbohydrates.		Ash.	Heat of combustion.
							Sugar, starch, etc.	Fiber.		
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
205a	Grapes, Tokay.....	4,835	481.07	4.02	25.14	5.80	434.18	15.95	11.12	2,040
202a	Grapes, Muscat....	649	83.45	.73	4.54	2.01	74.56	2.34	1.10	357
207a	Grapes, Cornichon	4,305	407.93	3.51	21.96	6.89	377.10	1.98	12.05	1,732
49	Olive oil.....	52	52.00	.....	.....	52.00	.....	.....	.....	483
32	Tomatoes.....	58	3.01	.08	.52	.23	1.91	.35	.29	14
240	Olives.....	113	35.15	.46	2.85	26.00	2.85	3.45	5.90	282
	Total.....	10,012	1,062.61	8.80	55.01	92.93	890.60	24.07	30.46	4,908
18a	Feces (water-free)	127.74	111.33	4.89	30.55	29.96	37.05	13.77	16.41	688
	Amount digested.....	.....	951.28	3.91	24.46	62.97	853.55	10.30	14.05	4,220
	Per cent digested.....	.....	89.52	44.43	44.46	67.76	95.84	42.80	46.13	86.00
	Energy of urine.....	.....	.....	.....	.....	.....	.....	.....	.....	31
	Energy of food oxidized in the body.....	.....	.....	.....	.....	.....	.....	.....	.....	4,189
	Per cent of energy utilized.....	.....	.....	.....	.....	.....	.....	.....	.....	85.35

During the experiment the subject eliminated 5,692 grams urine, containing 0.33 per cent or 18.69 grams nitrogen. The average nitrogen balance per day was therefore as follows: Income in food 8.8 grams; outgo in urine 4.67 grams, and in feces 1.22 grams; indicating a loss of 3.69 grams nitrogen, corresponding to 23.06 grams protein.



The diet of grapes only was so monotonous that it was hardly possible to consume the required quantity. To obviate this difficulty a small amount of olive oil and some olives and tomatoes were also eaten, the total nutrients supplied by these foods being small as compared with the grapes. The subject considered this diet quite appetizing. During the last two nights of the period, however, sleep was intermittent and toward morning a hunger was experienced.

#### DIGESTION EXPERIMENT NO. 389.

*Kind of food.*—Grapes and Brazil nuts, with small quantities of honey, milk, and olive oil.

*Subject.*—W. S. M.

*Weight (with clothing).*—At the beginning and end of the experiment, 56.2 kilograms (124 pounds).

*Duration.*—Four days, with twelve meals, beginning with breakfast November 26, 1901.

TABLE 16.—*Results of digestion experiment No. 389.*

Sample No.	Kind of food.	Weight of material.	Total organic matter.	Nitrogen.	Protein.	Fat.	Carbohydrates.		Ash.	Heat of combustion.
							Sugar, starch, etc.	Fiber.		
		Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Calories.
205a	Grapes, Tokay ....	1,315	130.84	1.09	6.84	1.58	118.08	4.34	3.03	554
202a	Grapes, Muscat ....	1,161	149.30	1.30	8.13	3.60	133.39	4.18	1.97	640
207a	Grapes, Cornichon ..	5,244	518.63	4.28	26.74	8.39	459.38	24.12	14.68	2,199
210	Brazil nuts .....	853	785.13	26.99	168.70	540.00	51.18	25.25	30.88	6,212
48	Honey .....	42	34.28	.06	.35	.....	33.93	.....	.09	137
9	Milk .....	52	6.39	.27	1.71	2.08	2.60	.....	.36	39
49	Olive oil .....	14	14.00	.....	.....	14.00	.....	.....	.....	130
	Total .....	8,681	1,638.57	33.99	212.47	569.65	798.56	57.89	51.01	9,911
22a	Feces (water-free) ..	152.84	131.80	5.38	33.64	50.15	39.56	8.45	21.04	894
	Amount digested .....	.....	1,506.77	28.61	178.83	519.50	759.00	49.44	29.97	9,017
	Per cent digested .....	.....	91.96	84.17	84.18	91.20	95.06	85.40	58.75	90.99
	Energy of urine .....	.....	.....	.....	.....	.....	.....	.....	.....	224
	Energy of food oxidized in the body .....	.....	.....	.....	.....	.....	.....	.....	.....	8,793
	Per cent of energy utilized .....	.....	.....	.....	.....	.....	.....	.....	.....	88.72

During the experiment the subject eliminated 4,229 grams of urine, containing 0.452 per cent or 18.77 grams nitrogen. The average nitrogen balance per day was therefore as follows: Income in food 8.50 grams; outgo in urine 4.69 grams, and in feces 1.38 grams; indicating a gain of 2.46 grams nitrogen, corresponding to 15.38 grams protein.

The subject believed himself to be amply nourished by the above diet, and found it more enjoyable at the close than at the commencement of the test.

## DIGESTION EXPERIMENT NO. 390.

*Kind of food.*—Grapes. Brazil nuts, and granose, with small quantities of tomatoes, milk, and olive oil.

*Subject.*—W. S. M.

*Weight (with clothing).*—At the beginning and end of the experiment, 56.2 kilograms (124 pounds).

*Duration.*—Four days, with twelve meals, beginning with breakfast December 3, 1901.

TABLE 17.—Results of digestion experiment No. 390.

Sample No.	Kind of food.	Weight of material.	Total organic matter.	Nitrogen.	Protein.	Fat.	Carbohydrates.		Ash.	Heat of combustion.
							Sugar, starch, etc.	Fiber.		
		Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Calories.
205a	Grapes, Tokay....	1,456	144.73	1.21	7.57	1.75	130.75	4.66	3.35	613
202a	Grapes, Muscat....	1,048	134.76	1.18	7.34	3.25	120.40	3.77	1.78	578
207a	Grapes, Cornichon	2,073	205.02	1.69	10.57	3.32	181.59	9.54	5.80	869
211a	Grapes, Verdial ..	1,166	130.48	.99	6.18	5.36	114.39	4.55	4.20	568
243	Granose .....	1,275	1,103.33	22.32	139.48	13.13	948.40	2.32	28.81	4,988
210	Brazil nuts .....	467	429.88	14.78	92.37	295.67	28.02	13.82	16.91	3,402
32	Tomatoes.....	118	6.13	.17	1.06	.47	3.89	.71	.59	29
9	Milk.....	57	7.01	.30	1.88	2.28	2.85	.....	.40	43
49	Olive oil.....	9	9.00	.....	.....	9.00	.....	.....	.....	84
	Total .....	7,669	2,170.34	42.64	266.45	334.23	1,530.29	39.37	61.84	11,174
26a	Feces (water-free)	168.51	145.33	6.21	38.80	52.41	39.07	15.05	23.18	943
	Amount digested.....	2,025.01	36.43	227.65	281.82	1,491.22	24.32	38.66	10,231	
	Per cent digested.....	93.31	85.44	85.44	84.32	97.45	61.77	62.52	91.56	
	Energy of urine .....									285
	Energy of food oxidized in the body .....									9,946
	Per cent of energy utilized.....									89.01

During the experiment the subject eliminated 4,995 grams urine, containing 0.438 per cent or 21.88 grams nitrogen. The average daily nitrogen balance was therefore as follows: Income in food 10.66 grams; outgo in urine 5.47 grams, and in feces 1.55 grams; indicating a gain of 3.64 grams nitrogen, or 22.75 grams protein.

The subject appeared to be well satisfied with this diet.

## DIGESTION EXPERIMENT NO. 393.

*Kind of food.*—Grapes and walnuts, with a small quantity of granose.

*Subject.*—W. S. M.

*Weight (with clothing).*—At the beginning of the experiment 55.8 kilograms (123 pounds) and at the close 55.3 kilograms (122 pounds).

*Duration.*—Four days, with twelve meals, beginning with breakfast December 10, 1901.

TABLE 18.—*Results of digestion experiment No. 393.*

[illegible]

During this experiment the subject eliminated 4,722 grams urine, containing 0.473 per cent or 22.34 grams nitrogen. The average nitrogen balance per day therefore was as follows: Income in food 8.62 grams; outgo in urine 5.59 grams, and in feces 1.74 grams; indicating a gain of 1.29 grams nitrogen, corresponding to 8.06 grams protein.

## DIGESTION EXPERIMENT NO. 394.

*Kind of food.*—Japanese persimmons and peanuts, supplemented by small quantities of tomatoes, granose, olive oil, and milk.

*Subject.*—W. S. M.

*Weight (with clothes).*—At the beginning and at the close of the experiment 56.2 kilograms (124 pounds).

*Duration.*—Four days, with twelve meals, commencing with breakfast December 18, 1901.

TABLE 19.—*Results of digestion experiment No 394.*

[illegible]

During this experiment the subject eliminated 4,538 grams urine, containing 0.652 per cent or 29.58 grams nitrogen. The average daily nitrogen balance therefore was as follows: Income in food 15 grams; outgo in urine 7.40 grams, and in feces 1.98 grams; indicating a gain of 5.62 nitrogen, corresponding to 35.12 grams protein.

This unusual diet was of the subject's own selection and apparently was satisfactory.

#### DIGESTION EXPERIMENT NO. 396.

*Kind of food.*—Pears and walnuts, with small quantities of granose and milk.

*Subject.*—W. S. M.

*Weight (with clothes).*—At the beginning of the experiment 57.1 kilograms (126 pounds) and at the close 56.7 kilograms (125 pounds).

*Duration.*—Four days, with twelve meals, beginning with breakfast December 26, 1901.

TABLE 20.—Results of digestion experiment No. 396.

Sample No.	Kind of food.	Weight of material.	Total organic matter	Nitrogen.	Protein.	Fat.	Carbohydrates.		Ash.	Heat of combustion.
							Sugar, starch, etc.	Fiber.		
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
51a	Pears .....	9,778	1,465.74	12.36	77.25	37.16	1,237.90	113.43	33.25	6,287
223	Walnuts .....	771	725.64	30.31	189.50	485.10	36.62	14.42	14.73	5,641
9	Milk .....	227	27.92	1.20	7.49	9.08	11.35	.....	1.59	171
243	Granose .....	113	99.64	1.98	12.36	1.16	84.06	2.06	2.55	444
	Total .....	10,889	2,318.94	45.85	286.60	532.50	1,369.93	129.91	52.12	12,542
49a	Feces (water-free) .....	184.48	168.38	7.29	45.57	45.73	41.72	35.36	16.10	1,061
	Amount digested .....	2,150.56	38.56	241.03	486.77	1,328.21	94.55	36.02	11,481	
	Per cent digested .....	92.74	84.10	84.10	91.41	96.98	72.80	69.11	91.54	301
	Energy of urine .....									
	Energy of food oxidized in the body .....									11,180
	Percent of energy utilized .....									89.12

During this experiment the subject eliminated 5,430 grams of urine, containing 0.397 per cent or 21.55 grams nitrogen. The average nitrogen balance per day was therefore as follows: Income in food 11.46 grams; outgo in urine 5.39 grams, and in feces 1.82 grams; indicating a gain of 4.25 grams nitrogen, corresponding to 26.56 grams protein.

#### DIGESTION EXPERIMENT NO. 398.

*Kind of food.*—Pears and cocoanuts chiefly, with cheese, tomatoes, and olive oil.

*Subject.*—W. S. M.

*Weight (with clothes).*—At the beginning of the experiment 57.1 kilograms (126 pounds) and at the close 56.3 kilograms (124.5 pounds).



*Duration.*—Four days, with twelve meals, beginning with breakfast January 6, 1902.

TABLE 21.—*Results of digestion experiment No. 398.*

Sample No.	Kind of food.	Weight of material.	Total organic matter.	Nitrogen.	Protein.	Fat.	Carbohydrates.		Ash.	Heat of combustion.
							Sugar, starch, etc.	Fiber.		
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
51a	Pears .....	9,986	1,496.91	12.62	78.89	37.95	1,264.23	115.84	33.95	6,421
231	Cocoanuts .....	971	773.77	8.16	50.98	495.20	93.89	133.70	11.07	5,804
11	Cottage cheese .....	57	14.93	1.91	11.91	.57	2.45	.....	1.03	81
32	Tomatoes .....	14	.73	.02	.13	.06	.46	.08	.07	5
49	Olive oil .....	63	63.00	.....	.....	63.00	.....	.....	.....	586
	Total .....	11,091	2,349.34	22.71	141.91	596.78	1,361.03	249.62	46.12	12,897
57a	Feces (water-free) .....	175.45	160.65	5.65	35.30	52.11	34.89	38.35	14.80	1,022
	Amount digested .....	2,188.69	17.06	106.61	544.67	1,326.14	211.27	31.32	11,875	
	Per cent digested .....	.....	93.16	75.12	75.12	91.27	97.44	84.64	67.91	92.09
	Energy of urine .....	.....	.....	.....	.....	.....	.....	.....	.....	133
	Energy of food oxidized in the body .....	.....	.....	.....	.....	.....	.....	.....	.....	11,742
	Percent of energy utilized .....	.....	.....	.....	.....	.....	.....	.....	.....	91.06

During this experiment the subject eliminated 6,792 grams urine, containing 0.344 per cent or 23.37 grams nitrogen. The average nitrogen balance per day was therefore as follows: Income in food 5.68 grams; outgo in urine 5.84 grams, and in feces 1.41 grams; indicating a loss of 1.57 grams nitrogen, corresponding to 8.81 grams protein.

The diet used in this experiment was chosen by the subject and proved appetizing. The pears were eaten in three different ways, i. e., raw, baked, and combined with tomatoes in a salad, which was dressed with a little olive oil.

#### DIGESTION EXPERIMENT NO. 401.

*Kind of food.*—Apples, dried figs, and walnuts, with some granose and milk.

*Subject.*—W. S. M.

*Weight (with clothes).*—At the beginning of the experiment 57.6 kilograms (127 pounds), and at the close 58.1 kilograms (128 pounds).

*Duration.*—Four days, with twelve meals, beginning with breakfast January 14, 1902.



TABLE 22.—*Results of digestion experiment No. 401.*

[illegible]

During this experiment the subject eliminated 5,645 grams urine, containing 0.424 per cent or 23.84 grams nitrogen. The average nitrogen balance per day was therefore as follows: Income in food 10.27 grams; outgo in urine 5.99 grams, and in feces 3 grams; indicating a gain of 1.28 grams nitrogen, corresponding to 8 grams protein.

## DIGESTION EXPERIMENT NO. 403.

*Kind of food.*—Apples, dates, and peanuts, with some granose, olive oil, tomatoes, and milk.

*Subject.*—W. S. M.

*Weight (with clothes).*—At the beginning of the experiment 58.1 kilograms (128 pounds) and at the close of the experiment 58.2 kilograms (128.5 pounds).

*Duration.*—Four days, with twelve meals, beginning with breakfast January 21, 1902.

TABLE 23.—*Results of digestion experiment No. 403.*

[illegible]

During this experiment the subject eliminated 5,893 grams urine, containing 0.503 per cent or 29.64 grams nitrogen. The average nitrogen balance per day was therefore as follows: Income in food 12.37 grams; outgo in urine 7.41 grams, and in feces 2.70 grams; indicating a gain of 2.26 grams nitrogen, corresponding to 14.13 grams protein.

#### DIGESTION EXPERIMENT NO. 405.

*Kind of food.*—Apples, dates, pecans, with a little granose and cottage cheese.

*Subject.*—W. S. M.

*Weight (with clothes).*—At the beginning and close of the experiment 59 kilograms (130 pounds).

*Duration.*—Four days, with twelve meals, beginning with breakfast January 28, 1902.

TABLE 24.—Results of digestion experiment No. 405.

Sample No.	Kind of food.	Weight of material.	Total organic matter.	Nitrogen.	Protein.	Fat.	Carbohydrates.		Ash.	Heat of combustion.
							Sugar, starch, etc.	Fiber.		
		Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Calories.
242a	Apples.....	8,305	1,248.24	7.31	45.68	10.80	1,103.73	88.03	13.29	5,145
37	Dates.....	1,365	771.22	5.90	36.85	4.10	701.60	28.67	17.75	3,182
233	Pecans.....	594	559.23	14.90	93.08	424.81	22.51	18.83	9.21	4,652
11	Cottage cheese.....	45	11.80	1.51	9.41	.45	1.94	.....	.81	65
243	Granose.....	45	39.68	.79	4.92	.46	33.48	.82	1.02	177
	Total.....	10,354	2,630.17	30.41	189.94	440.62	1,863.26	136.35	42.08	13,221
85a	Feces (water free).....	159.76	140.48	7.25	45.32	37.32	41.37	16.47	19.28	893
	Amount digested.....	2,489.69	23.16	144.62	403.30	1,821.89	119.88	22.80	12,328	
	Per cent digested.....	94.66	76.16	76.16	91.53	97.78	87.92	54.18	93.23	
	Energy of urine.....									181
	Energy of food oxidized in the body.....									12,147
	Percent of energy utilized.....									91.88

During this experiment the subject eliminated 5,648 grams urine, containing 0.413 per cent or 23.33 grams nitrogen. The average nitrogen balance per day was therefore as follows: Income in food 7.60 grams; outgo in urine 5.84 grams, and in feces 1.81 grams; indicating a loss of 0.05 gram nitrogen, corresponding to 0.31 gram protein.

Concerning the diet used in this test the subject stated that it was enjoyable throughout and eaten with increasing relish.

#### DIGESTION EXPERIMENT NO. 406.

*Kind of food.*—Apples, raisins, and walnuts, with peanuts, peanut butter, granose, cottage cheese, and butter.

*Subject.*—W. S. M.

*Weight (with clothes).*—At the beginning and close of the experiment 59.4 kilograms (131 pounds).

*Duration.*—Four days, with twelve meals, beginning with breakfast February 4, 1902.

TABLE 25.—*Results of digestion experiment No. 406.*

Sample No.	Kind of food.	Weight of material.	Total organic matter.	Nitrogen.	Protein.	Fat.	Carbohydrates.		Ash.	Heat of combustion.
							Sugar, starch, etc.	Fiber.		
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
242a	Apples.....	7,824	1,175.93	6.88	43.03	10.17	1,039.80	82.93	12.52	4,847
257	Raisins.....	1,338	915.05	9.74	60.88	8.16	837.18	8.83	42.01	3,941
223a	Walnuts.....	1,039	387.12	16.16	101.00	258.90	19.53	7.69	7.90	3,009
10	Butter.....	28	24.08	.05	.28	23.80	.....	.....	.08	325
243	Granofe.....	113	99.64	1.98	12.36	1.16	84.06	2.06	2.55	444
255	Peanuts.....	73	67.58	3.81	23.83	34.55	7.75	1.45	1.87	486
44	Peanut butter.....	59	54.81	2.77	17.29	27.43	10.09	.....	.30	395
11	Cottage cheese...	73	19.13	2.44	15.26	.73	3.14	.....	1.31	105
	Total.....	10,547	2,743.34	43.83	273.93	364.90	2,001.55	102.96	68.54	13,552
89a	Feces (water-free)	165.39	144.92	8.46	52.93	47.10	34.89	10.00	20.47	975
	Amount digested.....	.....	2,598.42	35.37	221.00	317.80	1,966.66	92.96	48.07	12,577
	Per cent digested.....	.....	94.72	80.70	80.68	87.10	98.25	90.30	70.14	92.80
	Energy of urine.....	.....	.....	.....	.....	.....	.....	.....	.....	276
	Energy of food oxidized in the body.....	.....	.....	.....	.....	.....	.....	.....	.....	12,301
	Percent of energy utilized.....	.....	.....	.....	.....	.....	.....	.....	.....	90.78

During this experiment the subject eliminated 5,055 grams urine, containing 0.446 per cent or 22.57 grams nitrogen. The average nitrogen balance per day was therefore as follows: Income in food 10.96 grams; outgo in urine 5.64 grams, and in feces 2.12 grams; indicating a gain of 3.20 grams nitrogen, corresponding to 20 grams protein.

The subject stated that the combination of fruits and nuts used in this test was quite satisfactory. The raisins were seeded and with the nuts made into a sort of mincemeat, which was eaten with great relish.

#### DISCUSSION OF DIGESTION EXPERIMENTS WITH SUBJECT W. S. M.

A study of the foregoing experiments brings to light a large amount of interesting data. In order to facilitate a review of these the results have been summarized in the following tables.

Table 26 shows the weight, composition, and fuel value of the food eaten per day during the different experiments; Table 27 summarizes the coefficients of digestibility for each of the eleven experiments, and Table 28 gives a summary of the income and outgo of nitrogen as determined for the individual experiments.

TABLE 26.—*Weight and composition of food per man per day.*

Ex- peri- ment No.	Kind of food.	Weight of ma- terial.	Total organic matter.	Nitro- gen.	Pro- tein.	Fat.	Carbohydrates.		Ash.	Heat of combus- tion.
							Sugar, starch, etc.	Fiber.		
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
388	Grapes, assorted...	2,503	265.65	2.20	13.75	23.23	222.65	6.02	7.61	1,047
389	Grapes, and Bra- zil nuts.....	2,170	409.64	8.50	53.12	142.41	199.64	14.47	12.75	2,198
390	Grapes, Brazil nuts, granose...	1,917	542.58	10.66	66.61	83.56	382.57	9.84	15.46	2,487
393	Grapes, walnuts, granose.....	2,172	394.97	8.62	53.87	116.26	213.65	11.19	10.72	2,017
391	Japanese persim- mons, peanuts (milk, 227grams)	2,151	504.31	15.00	93.74	120.80	255.98	33.79	15.54	2,400
396	Pears, walnuts, (milk, 227grams; granose, 113 grams) .....	2,722	579.74	11.46	71.65	133.13	342.48	32.48	13.03	2,795
398	Pears, cocoanut...	2,773	587.34	5.68	35.48	149.19	340.26	62.41	11.53	2,936
401	Dried figs, apples, walnuts.....	2,450	594.60	10.27	64.20	110.40	382.05	37.95	12.53	2,647
403	Apples, dates, peanuts.....	2,082	589.83	12.37	77.33	103.53	383.14	25.83	11.47	2,634
405	Apples, dates, pecans.....	2,589	657.58	7.60	47.48	110.15	465.86	34.09	10.52	3,037
406	Apples, raisins, walnuts .....	2,637	685.84	10.96	68.48	91.23	500.39	25.74	17.14	3,075
	Average, 11 experi- ments .....	2,379	528.37	9.39	58.70	107.63	335.33	26.71	12.58	2,479

TABLE 27.—*Summary of digestion experiments.*

Ex- peri- ment No.	Kind of food.	Total organic matter.	Protein.	Fat.	Carbohydrates.		Ash.	Energy avail- able.
					Sugar, starch etc.	Fiber.		
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
388	Grapes, with small amount of olive oil, tomatoes, and olives.....	89.52	44.43	67.76	95.84	42.80	46.13	85.35
389	Grapes, Brazil nuts .....	91.96	84.17	91.20	95.06	85.40	58.75	88.72
390	Grapes, Brazil nuts, granose.....	93.31	85.44	84.32	97.45	61.77	62.52	89.01
393	Grapes, walnuts, granose.....	91.77	79.76	89.49	97.18	70.06	52.80	88.18
394	Persimmons and peanuts (milk, 227 grams) .....	89.72	86.80	88.70	91.22	90.16	58.78	84.76
396	Pears, walnuts, milk, granose.....	92.74	84.10	91.41	96.98	72.80	69.11	89.12
398	Pears and cocoanut.....	93.16	75.12	91.27	97.44	84.64	67.91	91.06
401	Dried figs, apples, walnuts .....	91.86	70.79	88.22	97.85	77.95	44.48	87.87
403	Apples, dates, peanuts.....	91.70	78.14	83.29	97.16	84.96	46.15	86.70
405	Apples, dates, pecans.....	94.66	76.16	91.53	97.78	87.92	54.18	91.88
406	Apples, raisins, walnuts .....	94.72	80.70	87.10	98.25	90.30	70.14	90.78
	Average, 11 experiments.....	92.56	79.96	88.61	96.88	81.86	58.47	88.78



TABLE 28.—*Income and outgo of nitrogen.*

Ex- peri- ment No.	Kind of food.	Nitrogen.			
		In food.	In urine.	In feces.	Gain (+) or loss (-).
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
388	Grapes, assorted, whole period (4 days).....	8.80	18.69	4.89	-14.78
	Average for 1 day .....	2.20	4.67	1.22	- 3.69
389	Grapes, Brazil nuts, whole period (4 days).....	33.99	18.77	5.39	+ 9.83
	Average for 1 day .....	8.50	4.69	1.35	+ 2.46
390	Grapes, Brazil nuts, granose, whole period (4 days).....	42.64	21.88	6.21	+14.55
	Average for 1 day .....	10.66	5.47	1.55	+ 3.64
393	Grapes, walnuts, granose, whole period (4 days)....	34.49	22.34	6.98	+ 5.17
	Average for 1 day .....	8.62	5.59	1.74	+ 1.29
394	Persimmons, peanuts (milk, 227 grams), whole period (4 days) .....	60.00	29.58	7.93	+22.49
	Average for 1 day .....	15.00	7.40	1.98	+ 5.62
396	Pears, walnuts (milk, 227 grams; granose, 113 grams), whole period (4 days).....	45.85	21.55	7.29	+17.01
	Average for 1 day .....	11.46	5.39	1.82	+ 4.25
398	Pears, cocoanut, whole period (4 days).....	22.71	23.37	5.64	- 6.30
	Average for 1 day .....	5.68	5.84	1.41	- 1.57
401	Dried figs, apples, walnuts, whole period (4 days).....	41.08	23.94	12.01	+ 5.13
	Average for 1 day .....	10.27	5.99	3.00	+ 1.28
403	Apples, dates, peanuts, whole period (4 days).....	49.49	29.64	10.82	+ 9.03
	Average for 1 day .....	12.37	7.41	2.70	+ 2.26
405	Apples, dates, pecans, whole period (4 days).....	30.41	23.33	7.26	- .18
	Average for 1 day .....	7.60	5.83	1.81	- .05
406	Apples, raisins, walnuts, whole period (4 days)....	43.83	22.57	8.46	+12.80
	Average for 1 day .....	10.96	5.64	2.12	+ 3.20

In considering these and the succeeding digestion experiments it must be remembered that the digestibility of the food, and therefore the coefficients of digestibility, depend on many factors. The point has been so freely discussed in previous publications of this Office<sup>a</sup> that in this present instance it is not necessary to treat the matter in detail. It might not be out of place, however, to call to mind some of Prausnitz's<sup>b</sup> observations in this connection. He points out that there are three possibilities—either (1) each food digests as if it were used alone, or (2) one is hindered or (3) is helped in digestion by the presence of others. For the experiments under discussion the question is an exceedingly important one.

It appears from an examination of the data in Table 32 that in the first experiment, No. 388, in which the diet consisted entirely of grapes, the coefficients of availability for protein are extremely low. This may be accounted for in several ways. The protein of the grape may contain considerable amid nitrogen, although an examination of the data for the urine and feces would tend to an opposite view. The total amount of protein supplied by the food during the experimental period was 55 grams, while the feces contained 30.55 grams, or over 60 per cent, implying either a large amount of undigested protein or an unusual excretion of nitrogen in the so-called metabolic products. A reference, however, to Table 55, page 73, showing the metabolic nitrogen of the feces, indicates that for the experiment the feces contained about 1.3 grams of nitrogen in the so-called metabolic products, while the average of the 11 experiments is 1.35 grams. Whether the low

<sup>a</sup> U. S. Dept. Agr., Office of Experiment Stations Bul. 21, pp. 53-80. See also König's *Chemie der menschlichen Nahrungs- und Genussmittel*, 1889, p. 46.

<sup>b</sup> Arch. Hyg., 1893, p. 626.

coefficient obtained in this instance is due to the indigestibility of the grape protein, or whether it is a case of personal equation, or whether it is to be accounted for by the monotony of the diet, is one of the many questions which this investigation has given rise to.

The coefficient of digestibility for sugar, etc., is fairly high. That for the fat (ether extract) is low, but as we are not perfectly familiar with the composition of this material little can be said regarding its digestibility.

The food eaten in this experiment is less than a maintenance diet, as proved by the loss in body protein and total weight. The results obtained from experiment No. 389 are much more satisfactory in every way. The amount of protein was almost four times and the energy more than double the quantity ingested in the previous experiment. The coefficients of digestibility, 84 per cent for protein, 91 per cent for fat, 85 per cent for fiber, and 58 per cent for mineral matter, are all far higher than those reported for the grape experiment. This implies that the Brazil nut is quite thoroughly digested, at least by this subject. Whether like conditions would obtain with other subjects is a question for further study. The Brazil nut does not find as much favor with fruitarians generally as either the almond or walnut.

When walnuts were substituted for Brazil nuts, as in experiment No. 393, a decided lowering of the digestive coefficients was noticed, which tends to show that for this subject at least walnuts are not as well assimilated as Brazil nuts.

It is of more than passing interest to note the high digestibility observed in experiments Nos. 394 and 398 for a diet consisting in the main, respectively, of Japanese persimmons and peanuts and of pears and cocoanut. These two combinations are not usually considered to be inviting or appetizing even for one meal, yet this subject subsisted on each of them for four days. During the first test he gained 140 grams in body protein, while during the second he lost about 39 grams.

It appears from a consideration of experiment No. 401, in which the main foods used were apples, dried figs, and walnuts, and No. 406, where the diet consisted chiefly of apples, raisins, and walnuts, that the raisins were more thoroughly digested than the dried figs. This point is further emphasized by referring to Table 22, which shows for the period covered by experiment No. 401 a gain of 32 grams protein, while for experiment No. 406 a gain of 80 grams is recorded. The fact that the diet used in the latter experiment contained some peanuts and peanut butter may account to some extent for the increased digestibility but not for the great difference observed.

A comparison of the results of experiments Nos. 403 and 405, in which apples and dates were eaten, combined in the former test with peanuts and in the latter with pecans, indicates that for this subject there is little choice between the two nuts as regards digestibility. The main difference observed was in the fat.

The average coefficients of digestibility for the fruits and nuts in the above experiments made with this subject indicate that these foods possess a high nutritive value. This is shown further by the fact that during the entire experimental period of eleven weeks, from November 19, 1901, to February '7, 1902, while living upon a diet consisting mainly of fruit and nuts the subject gained 7 pounds in body weight.

It appears from Table 28 that the income of nitrogen in the food was, with the exception of experiment No. 394, generally low. The minimum quantity of nitrogen, recorded for experiment No. 388, namely, 2.2 grams per day, was naturally coexistent with the maximum loss. It would seem from the results of experiment No. 405 that with a diet furnishing about 4,400 calories of energy this subject required about 8 grams of nitrogen per day for the maintenance of nitrogen equilibrium, for with a daily income of 7.6 grams of nitrogen there was a loss of only 0.05 gram. In two experiments, Nos. 388 and 398, where the income fell still lower, there was a corresponding greater loss of body protein. In the remaining experiments, notwithstanding the small income of nitrogen, there is recorded an average daily gain varying from 1.28 grams of nitrogen in experiment No. 401 to 5.62 grams in experiment No. 394.

#### EXPERIMENTS WITH C. P. H.

The details follow of the digestion experiments made with C. P. H., who, as previously stated, was a man about 60 years old and in excellent health. For many years he had been accustomed to a diet similar to that eaten during the experimental period.

##### DIGESTION EXPERIMENT NO. 391.

*Kind of food.*—Bananas.

*Subject.*—C. P. H.

*Weight (with clothes).*—At the beginning and close of the experiment, 61.7 kilograms (136 pounds).

*Duration.*—Three days, with eight<sup>a</sup> meals, beginning with breakfast December 2, 1901.

TABLE 29.—*Results of digestion experiment No. 391.*

Sample No.	Kind of food.	Weight of material.	Total organic matter.	Nitrogen.	Protein.	Fat.	Carbohydrates.		Ash.	Heat of combustion.
							Sugar, starch, etc.	Fiber.		
		Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Calories.
212a	Bananas.....	6,520	906.28	10.53	65.85	9.78	809.13	21.52	33.25	3,839
29a	Feces (water-free)	57.40	50.21	2.52	15.78	7.93	24.22	2.28	7.19	296
	Amount digested.		856.07	8.01	50.07	1.85	784.91	19.24	26.06	3,543
	Per cent digested.			76.07	76.04	18.92	97.01	89.40	78.38	92.30
	Energy of urine									63
	Energy of food oxidized in the body									3,480
	Percent of energy utilized.									90.66

<sup>a</sup> This subject usually ate but two meals per day.





During this experiment the subject eliminated 3,750 grams urine, containing 0.553 per cent or 20.73 grams nitrogen. The average nitrogen balance per day was therefore as follows: Income in food 6.18 grams; outgo in urine 5.18 grams, and in feces 1.86 grams; indicating a loss of 0.86 gram nitrogen, corresponding to 5.38 grams protein.

During the first day of this test the subject ground the almonds to a fine paste, thereby causing a separation of the oil. This pasty mass, closely resembling peanut butter, did not digest well. During the succeeding three days he ate the nuts without grinding, and they seemed to digest more easily. The diet was appetizing and very satisfactory to the subject, who believed that he could follow it much longer than four days and also work hard, both physically and mentally.

The results of the experiment, however, do not bear out this belief. The nitrogen equilibrium was not kept up, the energy utilized was very low, and there was a slight loss of body weight.

#### DIGESTION EXPERIMENT NO. 395.

*Kind of food.*—Bananas and walnuts.

*Subject.*—C. P. H.

*Weight (with clothes).*—At the beginning of the experiment 63.2 kilograms (139.5 pounds), and at the close of the experiment 62.1 kilograms (137 pounds).

*Duration.*—Four days, with six meals, beginning with first meal December 18, 1901.

TABLE 31.—*Results of digestion experiment No. 395.*

Sample No.	Kind of food.	Weight of material.	Total organic matter.	Nitrogen.	Protein.	Fat.	Carbohydrates.		Ash.	Heat of combustion.
							Sugar, starch, etc.	Fiber.		
212a	Bananas.....	Grams. 6,180	Grams. 859.07	Grams. 9.99	Grams. 62.41	Grams. 9.27	Grams. 767.00	Grams. 20.39	Grams. 31.52	Calories. 3,637
223a	Walnuts.....	1,050	391.33	16.34	102.17	261.65	19.74	7.77	7.98	3,058
	Total.....	7,230	1,250.40	26.33	164.58	270.92	786.74	28.16	39.50	6,695
45a	Feces (water-free)	164.06	142.14	6.36	39.73	41.25	48.81	12.35	21.92	930
	Amount digested.....		1,108.26	19.97	124.85	229.67	737.93	15.81	17.58	5,765
	Per cent digested.....		88.60	75.85	75.85	84.79	93.80	56.12	44.52	84.85
	Energy of urine.....									156
	Energy of food oxidized in the body.....									5,609
	Percent of energy utilized.....									83.78

During this experiment the subject eliminated 2,790 grams urine, containing 0.644 per cent or 17.97 grams nitrogen. The average nitrogen balance per day was therefore as follows: Income in food 6.58 grams; outgo in urine 4.49 grams and in feces 1.59 grams; indicating a loss of 0.50 gram nitrogen, corresponding to 3.13 grams protein.

As above noted, only six meals were taken during this test—on the first day, one; on the second day and third day, two meals each; and on the fourth day, one meal.

The subject noticed that the diet used was monotonous, and that he did not look forward to mealtime with any degree of pleasurable anticipation. He also observed that while his general health remained good, when running up hill his legs became weak before reaching the top, which did not happen when using a diet of cereals, legumes, fruit, and nuts. Undoubtedly the loss of weight would have been much less and more meals would have been taken during the experiment had the subject been able to eat the food with more relish.

#### DIGESTION EXPERIMENT NO. 397.

*Kind of food.*—Apples and walnuts.

*Subject.*—C. P. H.

*Weight (with clothes).*—At the beginning of the experiment, 63.1 kilograms (139 pounds), and at the close of the experiment, 61.9 kilograms (136.5 pounds).

*Duration.*—Four days, with nine meals, beginning with breakfast December 26, 1901.

TABLE 32.—Results of digestion experiment No. 397.

Sample No.	Kind of food.	Weight of material.	Total organic matter.	Nitrogen.	Protein.	Fat.	Carbohydrates.		Ash.	Heat of combustion.
							Sugar, starch, etc.	Fiber.		
209a	Apples.....	Grams. 4,593	Grams. 467.56	Grams. 3.89	Grams. 24.34	Grams. 24.80	Grams. 375.70	Grams. 42.72	Grams. 11.02	Calories. 2,100
223a	Walnuts.....	1,589	592.23	24.74	154.60	596.03	29.87	11.76	12.08	4,599
	Total.....	6,182	1,059.79	28.63	178.94	420.80	405.57	54.48	23.10	6,699
53a	Feces (water-free)	215.45	183.24	10.75	67.18	70.49	33.66	11.91	32.21	1,276
	Amount digested.....		876.55	17.88	111.76	350.31	371.91	42.57	.....	5,423
	Per cent digested.....		82.72	62.46	62.46	83.25	91.70	78.14	.....	80.95
	Energy of urine.....									140
	Energy of food oxidized in the body.....									5,283
	Percent of energy utilized.....									78.86

During this experiment the subject eliminated 4,024 grams urine, containing 0.450 per cent or 18.14 grams nitrogen. The average nitrogen balance per day was therefore as follows: Income in food 7.18 grams; outgo in urine 4.53 grams, and in feces 2.69 grams; indicating a loss of 0.04 gram nitrogen, corresponding to 0.25 gram protein.

The subject stated that he did not find this diet as sustaining as when bananas were used in the place of apples. Usually two meals sufficed for the day's need, but on the second day of the experiment

he felt the necessity of a third meal, which was eaten about 7 p. m. In this instance the physiological results are entirely in accord with data of the test. The diet furnished only a small amount of nutriment, and as a natural consequence the subject felt weak and unable to perform his usual gymnastic exercises or to take his accustomed long walk.

#### DIGESTION EXPERIMENT NO. 399.

*Kind of food.*—Apples and almonds.

*Subject.*—C. P. H.

*Weight (with clothes).*—At the beginning of the experiment, 63.7 kilograms (140.5 pounds), and at the close, 61.9 kilograms (136.5 pounds).

*Duration.*—Four days, with eight meals, beginning with breakfast January 6, 1902.

TABLE 33.—Results of digestion experiment No. 399.

Sample No.	Kind of food.	Weight of material.	Total organic matter.	Nitrogen.	Protein.	Fat.	Carbohydrates.		Ash.	Heat of combustion.
							Sugar, starch, etc.	Fiber.		
209a 249	Apples.....	<i>Grams.</i> 5,840	<i>Grams.</i> 594.50	<i>Grams.</i> 5.04	<i>Grams.</i> 30.95	<i>Grams.</i> 31.53	<i>Grams.</i> 477.70	<i>Grams.</i> 54.32	<i>Grams.</i> 14.02	<i>Calories.</i> 2,683
	Almonds.....	851	789.69	23.53	147.04	462.10	158.60	21.95	23.66	5,883
	Total.....	6,691	1,384.19	28.57	177.99	493.63	636.30	76.27	37.68	8,566
61a	Feces (water-free)	162.48	144.10	7.29	45.56	58.00	26.45	14.09	18.38	1,018
	Amount digested.	6,528.52	1,240.10	21.28	132.43	435.63	609.85	62.18	19.30	7,548
	Per cent digested.		89.61	74.48	74.41	88.23	95.85	81.53	51.22	88.11
	Energy of urine									165
	Energy of food oxidized in the body.									7,383
	Per cent of energy utilized.									86.18

During this experiment the subject eliminated 5,125 grams urine, containing 0.399 per cent or 20.45 grams nitrogen. The average nitrogen balance per day was therefore as follows: Income in food 7.14; outgo in urine 5.11 grams, and in feces 1.82 grams; indicating a gain of 0.21 gram nitrogen, corresponding to 1.31 grams protein.

The subject drank no water during this experiment and although apples are quite succulent and supply considerable water, the lack of it as a beverage may tend to account to some extent for the loss of 4 pounds in body weight. The fact that there was such a decrease in weight combined with a slight increase in protein would seem to warrant such a conclusion.

The subject found himself becoming steadily weaker as the experiment continued. He omitted much of his usual exercise and considerably shortened his daily walk.

## DIGESTION EXPERIMENT NO. 400.

*Kind of food.*—Apples, bananas, walnuts.

*Subject.*—C. P. H.

*Weight (with clothes).*—At the beginning of the experiment, 64 kilograms (141 pounds), and at the close, 64.2 kilograms (141.5 pounds).

*Duration.*—Four days, with eight meals, beginning with breakfast January 14, 1902.

TABLE 34.—Results of digestion experiment No. 400.

Sam- ple No.	Kind of food.	Weight of ma- terial.	Total organic matter.	Nitro- gen.	Pro- tein.	Fat.	Carbohydrates.		Ash.	Heat of combustion.
							Sugar, starch, etc.	Fiber.		
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
209a	Apples.....	3,968	403.97	3.36	21.04	21.43	324.60	36.90	9.52	1,820
212a	Bananas.....	4,196	583.24	6.78	42.38	6.29	520.72	13.85	21.40	2,470
223a	Walnuts.....	1,531	570.60	23.84	148.97	381.52	28.78	11.33	11.63	4,441
	Total.....	9,695	1,557.81	33.98	212.39	409.24	874.10	62.08	42.55	8,731
65a	Feces (water-free)	176.47	151.23	8.63	53.91	40.28	48.14	8.90	25.24	1,006
	Amount digested.	1,406.58	25.35	158.48	368.96	825.96	53.18	17.81	17.81	7,725
	Per cent digested.	90.30	74.61	74.61	90.15	94.48	85.66	40.68	40.68	88.47
	Energy of urine.									198
	Energy of food oxidized in the body.									7,527
	Percent of energy utilized.									86.20

During this experiment the subject eliminated 3,350 grams urine, containing 0.575 per cent or 19.30 grams nitrogen. The average nitrogen balance per day was therefore as follows: Income in food 8.51 grams; outgo in urine 4.82 grams, and in feces 2.16 grams; indicating a gain of 1.53 grams nitrogen or 9.56 grams protein.

The bananas were sliced and cooked to a mush without adding water or salt. They were found to be more palatable than when eaten either raw or toasted.

This test was much more satisfactory than the previous one in many ways. The weight was slightly increased and there was an appreciable gain in protein. The subject remained in good physical condition during the entire experimental period, exercising and taking long walks. On the second day he ran almost a mile in six minutes, and remarked that he could have kept up the exercise longer. He also performed considerable mental work during the four-day experiment, writing as late as midnight on two occasions.



## DIGESTION EXPERIMENT NO. 402.

*Kind of food.*—Apples, bananas, almonds.

*Subject.*—C. P. H.

*Weight (with clothes).*—At the beginning and end of the experiment, 64.2 kilograms (141.5 pounds).

*Duration.*—Four days, with eight meals, beginning with breakfast January 21, 1902.

TABLE 35.—Results of digestion experiment No. 402.

Sample No.	Kind of food.	Weight of material.	Total organic matter.	Nitrogen.	Protein.	Fat.	Carbohydrates.		Ash.	Heat of combustion.
							Sugar, starch, etc.	Fiber.		
		Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Calories.
209a	Apples.....	3,515	357.81	2.98	18.63	18.98	287.51	32.69	8.44	1,612
212a	Bananas.....	3,572	496.52	5.77	36.07	5.36	443.30	11.79	18.22	2,100
249	Almonds.....	1,333	1,236.98	36.85	230.32	723.80	248.47	34.39	37.06	9,199
	Total.....	8,420	2,091.31	45.60	285.02	748.14	979.28	78.87	63.72	12,911
73a	Feces (water-free)	205.35	177.81	9.16	57.20	61.09	46.56	12.96	27.54	1,244
	Amount digested.....		1,913.50	36.44	227.82	687.05	932.72	65.91	36.18	11,667
	Per cent digested.....		91.51	79.93	79.93	91.84	95.24	83.57	57.25	90.36
	Energy of urine.....									285
	Energy of food oxidized in the body.....									11,382
	Per cent of energy utilized.....									88.15

During this experiment the subject eliminated 4,253 grams urine, containing 0.469 per cent or 19.97 grams nitrogen. The average nitrogen balance per day was therefore as follows: Income in food 11.41 grams; outgo in urine 4.94 grams, and in feces 2.29 grams; indicating a gain of 4.13 grams nitrogen, corresponding to 25.81 grams protein.

The diet of apples, bananas, and almonds was eaten with considerable relish. The subject believed that he could, if necessary, maintain his condition on this diet; but for the sake of variety he felt that it would be well to add food made from cereals and relishes, such as honey, etc. On such a diet he believed he could perform heavy manual labor. During the study he exercised a great deal every day, and was also occupied with considerable mental work.

## DIGESTION EXPERIMENT NO. 404.

*Kind of food.*—Apples, bananas, and Brazil nuts.

*Subject.*—C. P. H.

*Weight (with clothes).*—At the beginning of the experiment, 64 kilograms (141 pounds), and at the close 63.5 kilograms (140 pounds).

*Duration.*—Four days with eight meals, beginning with breakfast January 28, 1902.



During this experiment the subject eliminated 4,776 grams urine, containing 0.607 per cent or 29.02 grams nitrogen. The average nitrogen balance per day was therefore as follows: Income in food 5.68 grams; outgo in urine 7.25 grams, and in feces 1.73 grams; indicating a loss of 3.30 grams nitrogen, corresponding to 20.63 grams protein.

From the above results it appears that the diet during this test was less sustaining than that used in experiment No. 404. The subject had been suffering from a slight laxative condition, which quickly disappeared upon the present diet. The general impression is that fruits are more or less of a cure for constipation, but in the case of this subject the combination of fruit and nuts had the opposite effect.

The subject during this test again felt a craving for some kind of cereal food, but maintained his usual good health and spirits, notwithstanding the loss of body protein. Had the experiment lasted for eight or ten days this probably would not have been the case.

#### DIGESTION EXPERIMENT NO. 408.

*Kind of food.*—Apples, bananas, pecans, and granose.

*Subject.*—C. P. H.

*Weight (with clothes).*—At the beginning of the experiment, 64.6 kilograms (142.5 pounds), and at the close, 64.2 kilograms (141.5 pounds).

*Duration.*—Four days, with eight meals, beginning with breakfast February 11, 1902.

TABLE 38.—Results of digestion experiment No. 408.

Sample No.	Kind of food.	Weight of material.	Total organic matter.	Nitrogen.	Protein.	Fat.	Carbohydrates.		Ash.	Heat of combustion.
							Sugar, starch, etc.	Fiber.		
209a	Apples .....	568	57.82	0.48	3.01	3.07	46.46	5.28	1.36	260
212a	Bananas .....	2,042	283.82	3.30	20.62	3.06	253.40	6.74	10.41	1,203
233	Pecans .....	340	320.10	8.52	53.28	243.15	12.89	10.78	5.27	2,663
243	Granose .....	992	874.74	17.37	108.52	10.22	737.95	18.05	22.42	3,887
	Total .....	3,942	1,536.48	29.67	185.43	259.50	1,050.70	40.85	39.46	8,013
97a	Feces (water-free) .....	264.50	225.35	10.64	66.49	48.16	83.68	27.02	39.15	1,374
	Amount digested .....	1,311.13	19.03	118.94	211.34	967.02	13.83	0.31		6,639
	Per cent digested .....	85.34	64.16	64.16	81.45	92.04	33.86			82.88
	Energy of urine .....									149
	Energy of food oxidized in the body .....									6,490
	Percent of energy utilized .....									81.02

During this experiment the subject eliminated 3,209 grams urine, containing 0.980 per cent or 31.43 grams nitrogen. The average nitrogen balance per day was therefore as follows: Income in food 7.42 grams; outgo in urine 7.86 grams, and in feces 2.66 grams; indicating a loss of 3.10 grams, corresponding to 19.38 grams protein.

A thick pudding was made of the bananas cooked in their own juice with the addition of granose. This dish the subject declared to be very palatable and satisfying. The apples were eaten either baked or stewed. The subject considered this diet very palatable and did not crave any other foods.

#### DIGESTION EXPERIMENT NO. 409.

*Kind of food.*—Oranges, bananas, pecans.

*Subject.*—C. P. H.

*Weight (with clothes).*—At the beginning of the experiment, 64.9 kilograms (143 pounds), and at the close, 64.2 kilograms (141.5 pounds).

*Duration.*—Four days, with eight meals, beginning with breakfast February 18, 1902.

TABLE 39.—Results of digestion experiment No. 409.

Sample No.	Kind of food.	Weight of material.	Total organic matter.	Nitrogen.	Protein.	Fat.	Carbohydrates.		Ash.	Heat of combustion.
							Sugar, starch, etc.	Fiber.		
238a	Oranges .....	Grams. 2,381	Grams. 227.86	Grams. 3.57	Grams. 22.38	Grams. 3.10	Grams. 191.90	Grams. 10.48	Grams. 11.19	Calories. 964
212a	Bananas .....	4,480	622.76	7.24	45.25	6.72	556.00	14.79	22.85	2,638
233	Pecans .....	567	533.81	14.21	88.85	405.50	21.49	17.97	8.79	4,439
	Total .....	7,428	1,384.43	25.02	156.48	415.32	769.39	43.24	42.83	8,041
101a	Feces (water-free) .....	163.20	141.01	7.33	45.80	41.69	43.11	10.41	22.19	900
	Amount digested .....		1,243.42	17.69	110.68	373.63	726.28	32.83	20.64	7,141
	Per cent digested .....		89.82	70.70	70.72	89.96	94.40	75.93	48.19	88.80
	Energy of urine .....									138
	Energy of food oxidized in the body .....									
	Percent of energy utilized .....									7,003
										87.12

During this experiment the subject eliminated 6,006 grams urine, containing 0.407 per cent or 24.46 grams nitrogen. The average nitrogen balance per day was therefore as follows: Income in food 6.25 grams; outgo in urine 6.11 grams, and in feces 1.83 grams; indicating a loss of 1.69 grams nitrogen, corresponding to 10.56 grams protein.

It was noted by the subject that the diet used in this test was very "weakening." It had been his custom to exercise an hour each day by climbing a steep hill, and to run part of the distance. This he could do without difficulty when on a diet which includes cereals, but not on the diet used in the present test.

#### DIGESTION EXPERIMENT NO. 410.

*Kind of food.*—Oranges, bananas, pecans, granose.

*Subject.*—C. P. H.

*Weight (with clothes).*—At the beginning of the experiment, 64.2 kilograms (141.5 pounds), and at the close, 63.7 kilograms (140.5 pounds).

*Duration.*—Four days, with eight meals, beginning with breakfast February 25, 1902.



TABLE 40.—Results of digestion experiment No. 410.

Sample No.	Kind of food.	Weight of material.	Total organic matter.	Nitrogen.	Protein.	Fat.	Carbohydrates.		Ash.	Heat of combustion.
							Sugar, starch, etc.	Fiber.		
212a	Bananas.....	Grams. 3,968	Grams. 551.51	Grams. 6.41	Grams. 40.07	Grams. 5.95	Grams. 492.40	Grams. 13.09	Grams. 20.24	Calories. 2,336
238a	Oranges.....	1,418	135.71	2.13	13.33	1.84	114.30	6.24	6.66	582
233	Pecans.....	290	273.02	7.27	45.44	207.40	10.99	9.19	4.50	2,273
243	Granose.....	880	775.96	15.41	96.26	9.06	654.62	16.02	19.89	3,444
	Total.....	6,556	1,736.20	31.22	195.10	224.25	1,272.31	44.54	51.29	8,635
105a	Feces (water-free)	229.88	196.74	9.40	58.75	39.86	73.09	25.04	33.15	1,165
	Amount digested.....	1,539.46	21.82	136.37	184.39	1,199.22	19.50	18.14	7,470	
	Per cent digested.....	88.67	69.89	69.89	82.23	94.26	43.78	35.37	86.51	171
	Energy of urine.....									171
	Energy of food oxidized in the body.....									7,299
	Percent of energy utilized.....									84.53

During this experiment the subject eliminated 5,372 grams urine, containing 0.589 per cent or 31.63 grams nitrogen. The average nitrogen balance per day was therefore as follows: Income in food 7.81 grams; outgo in urine 7.91 grams, and in feces 2.35 grams; indicating a loss of 2.45 grams nitrogen, corresponding to 15.31 grams protein.

## DIGESTION EXPERIMENT NO. 411.

*Kind of food.*—Oranges, dried prunes, walnuts.

*Subject.*—C. P. H.

*Weight (with clothes).*—At the beginning of experiment, 65.8 kilograms (145 pounds), and at the close, 64.0 kilograms (141 pounds).

*Duration.*—Three days, with six meals, beginning with breakfast March 4, 1902.

TABLE 41.—Results of digestion experiment No. 411.

Sample No.	Kind of food.	Weight of material.	Total organic matter.	Nitrogen.	Protein.	Fat.	Carbohydrates.		Ash.	Heat of combustion.
							Sugar, starch, etc.	Fiber.		
238a	Oranges.....	Grams. 1,532	Grams. 146.62	Grams. 2.30	Grams. 14.40	Grams. 1.99	Grams. 123.49	Grams. 6.74	Grams. 7.20	Calories. 628
256a	Prunes.....	1,587	952.81	5.69	35.55	8.25	886.00	23.01	37.93	3,990
223a	Walnuts.....	1,388	517.32	21.61	135.06	345.90	26.09	10.27	10.55	4,021
	Total.....	4,507	1,616.75	29.60	185.01	356.14	1,035.58	40.02	55.68	8,639
108a	Feces (water-free)	117.41	104.51	4.92	30.76	41.51	25.79	6.45	12.90	709
	Amount digested.....	1,512.24	24.68	154.25	314.63	1,009.79	33.57	42.78	7,930	
	Per cent digested.....	93.53	83.38	83.38	88.34	97.48	83.89	76.85	91.80	193
	Energy of urine.....									193
	Energy of food oxidized in the body.....									7,737
	Percent of energy utilized.....									89.58

During this experiment the subject eliminated 2,195 grams urine, containing 0.657 per cent or 14.42 grams nitrogen. The average

nitrogen balance per day was therefore as follows: Income in food 9.87 grams; outgo in urine 4.81 grams, and in feces 1.64 grams; indicating a gain of 3.42 grams nitrogen, or 21.38 grams protein.

This experiment was originally planned as a four-day test, but owing to the laxative character of the diet, which the subject attributed to the prunes, it was deemed advisable to shorten it to three days. The subject noted that while this diet did not make him ill, it did cause him to feel very weak. Had a smaller quantity of prunes been used, perhaps the results would have been different.

Notwithstanding this intestinal trouble and loss of body weight, the results indicate an appreciable gain of body protein. This is more important than the loss of body weight, which was presumably due to the loss of fluids occasioned by the diarrhea.

#### DIGESTION EXPERIMENT NO. 412.

*Kind of food.*—Dates, olives (pickled ripe), walnuts.

*Subject.*—C. P. H.

*Weight (with clothes).*—At the beginning of the experiment, 63.5 kilograms (140 pounds), and at the close, 64.4 kilograms (142 pounds).

*Duration.*—Four days, with eight meals, beginning with breakfast March 11, 1902.

TABLE 42.—Results of digestion experiment No. 412.

Sam- ple No.	Kind of food.	Weight of ma- terial.	Total organic matter.	Nitro- gen.	Pro- tein.	Fat.	Carbohydrates.		Ash.	Heat of combustion.
							Sugar, starch, etc.	Fiber.		
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
37	Dates .....	2,129	1,202.88	9.20	57.48	6.39	1,094.30	44.71	27.68	4,957
240a	Olives .....	908	228.88	2.96	18.52	169.41	18.52	22.43	38.40	1,752
223a	Walnuts .....	623	232.14	9.71	66.62	155.20	11.71	4.61	4.74	1,800
	Total .....	3,660	1,663.90	21.87	136.62	331.00	1,124.53	71.75	70.82	8,509
112a	Feces (water-free) .....	284.76	255.35	8.79	54.92	71.45	108.52	20.46	29.41	1,702
	Amount digested .....	1,408.56	13.08	81.70	259.55	1,016.01	51.29	41.41	6,807	
	Per cent digested .....	84.71	59.81	59.81	78.41	90.35	71.48	58.47	80.00	
	Energy of urine .....									102
	Energy of food oxidized in the body .....									6,705
	Per cent of energy utilized .....									78.80

During this experiment the subject eliminated 3,665 grams urine, containing 0.523 per cent or 19.15 grams nitrogen. The average nitrogen balance per day was therefore as follows: Income in food 5.47 grams; outgo in urine 4.79 grams, and in feces 2.20 grams; indicating a loss of 1.52 grams nitrogen, corresponding to 9.50 grams protein.

The subject believed the combination of dates, olives, and nuts to be an ideal fruit diet for him; and his physical condition and the fact that

he increased his weight during the experimental period showed that at least it agreed with him. In order, however, that the nitrogen equilibrium be maintained the proportion of nuts in the diet should have been increased.

#### DIGESTION EXPERIMENT NO. 413.

*Kind of food.*—Dates, olives, and almonds.

*Subject.*—C. P. H.

*Weight (with clothes).*—At the beginning of the experiment, 64.4 kilograms (142 pounds), and at the close, 64.0 kilograms (141 pounds).

*Duration.*—Four days, with eight meals, beginning with breakfast March 18, 1902.

TABLE 43.—Results of digestion experiment No 413.

Sample No.	Kind of food.	Weight of material.	Total organic matter.	Nitrogen.	Protein.	Fat.	Carbohydrates.		Ash.	Heat of combustion.
							Sugar, starch, etc.	Fiber.		
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
37	Dates .....	2,494	1,409.08	10.78	67.33	7.48	1,281.90	52.37	32.42	5,814
240a	Olives .....	1,389	350.18	4.53	28.33	259.20	28.34	34.31	58.75	2,681
249	Almonds .....	312	289.53	8.63	53.92	169.40	58.16	8.05	8.67	2,159
	Total .....	4,195	2,048.79	23.94	149.58	436.08	1,368.40	94.73	99.84	10,654
116a	Feces (water-free) .....	282.50	252.53	8.18	51.17	73.17	107.66	20.53	29.97	1,747
	Amount digested .....	1,796.26	15.76	98.41	362.91	1,260.74	74.20	69.87	83.60	8,907
	Per cent digested .....	87.68	65.84	65.80	83.22	92.14	78.34	69.98		83.60
	Energy of urine .....									123
	Energy of food oxidized in the body .....									8,784
	Per cent of energy utilized .....									82.45

During this experiment the subject eliminated 4,156 grams urine, containing 0.577 per cent or 23.97 grams nitrogen. The average nitrogen balance per day was therefore as follows: Income in food 5.98 grams; outgo in urine 5.99 grams, and in feces 2.05 grams; indicating a loss of 2.06 grams nitrogen, corresponding to 12.88 grams protein.

The subject seemed to relish the diet. The only criticism made was that for a longer period the diet would have been greatly improved by the addition of some cereal food. If the kind of food was unchanged more nuts would have been required to maintain nitrogen equilibrium.

#### DIGESTION EXPERIMENT NO. 414.

*Kind of food.*—Dates, olives (pickled ripe), almonds, granose.

*Subject.*—C. P. H.

*Weight (with clothes).*—At the beginning of the experiment, 63.5 kilograms (140 pounds), and at the close, 64.6 kilograms (142.5 pounds).

*Duration.*—Four days, with eight meals, beginning with breakfast March 25, 1902.

TABLE 44.—*Results of digestion experiment No. 414.*

Sample No.	Kind of food.	Weight of material.	Total organic matter.	Nitrogen.	Protein.	Fat.	Carbohydrates.		Ash.	Heat of combustion.
							Sugar, starch, etc.	Fiber.		
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
37	Dates .....	1,502	848.61	6.49	40.56	4.51	772.00	31.54	19.53	3,499
249	Almonds .....	340	315.51	9.40	58.76	184.60	63.38	8.77	9.45	2,347
240a	Olives .....	566	142.69	1.85	11.55	105.61	11.55	13.93	23.94	1,095
243	Granose .....	680	144.35	11.90	74.39	7.00	50.58	12.38	15.37	2,663
	Total .....	3,088	1,451.16	29.64	185.26	301.72	897.51	66.67	68.29	9,604
120a	Feces (water-free) .....	283.34	252.98	8.96	56.03	75.20	97.37	24.38	30.36	1,674
	Amount digested .....		1,192.18	20.68	129.23	226.52	800.14	42.29	37.93	7,930
	Per cent digested .....		82.15	69.77	69.76	75.08	89.15	63.42	55.54	82.59
	Energy of urine .....									162
	Energy of food oxidized in the body .....									7,768
	Percent of energy utilized .....									80.89

During this experiment the subject eliminated 3,431 grams urine, containing 0.657 per cent or 22.56 grams nitrogen. The average nitrogen balance per day was therefore as follows: Income in food 7.41 grams; outgo in urine 5.64 grams, and in feces 2.24 grams; indicating a loss of 0.47 gram nitrogen, corresponding to 2.94 grams protein.

The subject was well pleased with the diet used in this experiment, but stated that he would have relished occasionally a few green vegetables or some ripe, fresh fruit in addition.

#### DIGESTION EXPERIMENT NO. 415.

*Kind of food.*—Gofio<sup>a</sup> (a parched cereal preparation).

*Subject.*—C. P. H.

*Weight (with clothes).*—At the beginning of the experiment, 64.0 kilograms (141 pounds), and at the close, 63.1 kilograms (139 pounds).

*Duration.*—Three days, with seven meals, beginning with breakfast April 1, 1902.

TABLE 45.—*Results of digestion experiment No. 415.*

Sample No.	Kind of food.	Weight of material.	Total organic matter.	Nitrogen.	Protein.	Fat.	Carbohydrates.		Ash.	Heat of combustion.
							Sugar, starch, etc.	Fiber.		
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
246	Gofio (a parched cereal preparation) .....	1,305	1,190.39	26.87	167.94	36.80	919.10	66.55	31.45	5,414
122a	Feces (water-free) .....	137.30	123.02	6.51	40.72	10.58	52.66	19.06	14.28	672
	Amount digested .....		1,067.37	20.36	127.22	26.22	866.44	47.49	17.17	4,742
	Per cent digested .....		89.66	75.77	75.77	71.25	94.27	71.36	54.60	87.59
	Energy of urine .....									159
	Energy of food oxidized in the body .....									4,583
	Percent of energy utilized .....									84.64

<sup>a</sup> See description of samples No. 246, p. 8.



During this experiment the subject eliminated 2,872 grams urine, containing 0.601 per cent or 17.26 grams nitrogen. The average nitrogen balance per day was therefore as follows: Income in food 8.95 grams; outgo in urine 5.75 grams, and in feces 2.17 grams; indicating a gain of 1.03 grams nitrogen, corresponding to 6.44 grams protein.

As previously stated, gofio is a mixture of cereals roasted and ground, which is quite commonly eaten in the Canary Islands.

A diet consisting of only one article of food—and an unpalatable one at that—can not be satisfying, and it is natural that the subject experienced some difficulty in carrying out the experiment. The nitrogen equilibrium, however, was more than maintained, although there was a decrease of 2 pounds in the body weight. During the experimental period the subject worked a long time each day at gardening.

#### DISCUSSION OF DIGESTION EXPERIMENTS WITH SUBJECT C. P. H.

The results obtained in the digestion experiments with subject C. P. H. are summarized below, Table 46 showing the weight and composition of the food eaten per day, Table 47 the percentages digested, and Table 48 the balance of income and outgo of nitrogen during the periods covered by the digestion experiments.

TABLE 46.—*Weight and composition of food per man per day.*<sup>c</sup>

Ex- peri- ment No.	Kind of food.	Weight of ma- terial.	Total organic matter.	Nitro- gen.	Pro- tein.	Fat.	Carbohydrates.		Ash.	Heat of combustion.
							Sugar, starch, etc.	Crude fiber.		
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
391	Bananas.....	2, 173	302.09	3.51	21.95	3.26	269.71	7.17	11.08	1, 160
392	Bananas and al- monds.....	1, 885	356.86	6.18	38.60	67.95	241.39	8.92	12.34	1, 601
395	Bananas and wal- nuts.....	1, 808	312.60	6.58	41.14	67.73	196.69	7.04	9.88	1, 402
397	Apples and wal- nuts.....	1, 546	264.95	7.16	44.74	105.20	101.39	13.62	5.77	1, 322
399	Apples and al- monds.....	1, 673	346.06	7.13	44.50	123.41	159.08	19.07	9.42	1, 844
400	Apples, bananas, and walnuts....	2, 424	389.45	8.50	53.10	102.31	218.52	15.52	10.64	1, 882
402	Apples, bananas, and almonds...	2, 105	522.83	11.41	71.25	187.04	244.82	19.72	15.93	2, 845
404	Apples, bananas, and Brazil nuts.	2, 559	383.23	6.35	39.69	92.67	229.02	21.85	11.25	1, 854
407	Apples, bananas, and pecans.....	2, 345	378.65	5.66	35.36	88.35	237.82	17.12	10.36	1, 792
408	Apples, bananas, pecans, and granose.....	1, 011	384.11	7.42	46.36	64.87	262.67	10.21	9.86	1, 623
409	Oranges, bananas, and pecans.....	1, 857	346.11	6.26	39.12	103.83	192.35	10.81	10.71	1, 751
410	Oranges, bananas, pecans, granose.	1, 639	434.06	7.80	48.78	56.06	318.08	11.14	12.82	1, 825
411	Oranges, prunes, walnuts.....	1, 502	538.91	9.87	61.67	118.71	345.19	13.34	18.56	2, 579
412	Dates, olives, walnuts.....	915	415.97	5.47	34.15	82.75	281.13	17.94	17.70	1, 676
413	Dates, olives, al- monds.....	1, 049	512.19	5.98	37.39	109.02	342.10	23.68	24.96	2, 196
414	Dates, olives, al- monds, granose.	772	362.79	7.41	46.31	75.43	224.38	16.67	17.07	1, 942
	Average of 16 experi- ments....	1, 704	390.67	7.04	44.01	90.56	241.52	14.48	<sup>b</sup> 13.77	1, 831

<sup>a</sup> With the exception of Nos. 391 and 411, representing averages of three-day trials, the figures per day represent the averages of four-day tests.

<sup>b</sup> Ash of Nos. 397 and 408 not included in average.

TABLE 47.—*Summary of digestion experiments.*

Ex- peri- ment No.	Kind of food.	Total organic matter.	Protein.	Fat.	Carbohydrates.		Ash.	Heat of com- bus- tion.
					Sugar, starch, etc.	Fiber.		
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
391	Bananas .....	94.46	76.04	18.92	97.01	89.40	78.38	90.66
392	Bananas and almonds .....	89.91	70.00	84.70	95.13	76.59	42.19	85.73
395	Bananas and walnuts .....	88.60	75.85	84.79	93.80	56.12	44.52	83.78
397	Apples and walnuts .....	82.72	62.46	83.25	91.70	78.14	.....	78.86
399	Apples and almonds .....	89.61	74.41	88.23	95.85	81.53	51.22	86.18
400	Apples, bananas, and walnuts .....	90.30	74.61	90.15	94.48	85.66	40.68	86.20
402	Apples, bananas, and almonds .....	91.51	79.93	91.84	95.24	83.57	57.25	88.15
404	Apples, bananas, and Brazil nuts .....	90.04	75.34	91.47	92.98	79.62	34.51	86.61
407	Apples, bananas, and pecans .....	90.15	69.46	88.19	94.24	86.16	40.85	86.65
408	Apples, bananas, pecans, granose .....	85.34	64.16	81.45	92.04	33.86	.....	81.02
409	Oranges, bananas, pecans .....	89.82	70.70	89.96	94.40	75.93	48.19	87.12
410	Bananas, oranges, pecans, granose .....	88.67	69.89	82.23	94.26	48.78	35.37	84.53
411	Oranges, prunes and walnuts .....	93.53	83.38	88.34	97.48	83.89	76.85	89.58
412	Dates, olives, and walnuts .....	84.71	59.81	78.41	90.35	71.48	58.47	78.79
413	Dates, olives, and almonds .....	87.68	65.84	83.22	92.14	78.34	69.98	82.45
414	Dates, almonds, olives, and gra- nose .....	82.15	69.77	75.08	89.15	63.42	55.54	80.89
	Average of 16 experiments..	88.71	71.76	86.16	93.70	74.60	54.02	84.76

a Average of 14 experiments.

TABLE 48.—*Income and outgo of nitrogen.*

Ex- peri- ment No.	Kind of food.	Nitrogen.			
		In food.	In urine.	In feces.	Gain (+) or loss (-).
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
391	Bananas, whole period (3 days) .....	10.53	12.03	2.53	- 4.03
	Average for 1 day .....	3.51	4.01	.84	- 1.34
392	Bananas and almonds, whole period (4 days) .....	24.71	20.73	7.42	- 3.44
	Average for 1 day .....	6.18	5.18	1.86	- .86
395	Bananas and walnuts, whole period (4 days) .....	26.33	17.97	6.36	+ 2.00
	Average for 1 day .....	6.58	4.49	1.59	+ .50
397	Apples and walnuts, whole period (4 days) .....	28.63	18.14	10.75	- .26
	Average for 1 day .....	7.16	4.53	2.69	- .07
399	Apples and almonds, whole period (4 days) .....	28.57	20.45	7.29	+ .83
	Average for 1 day .....	7.14	5.11	1.82	+ .21
400	Apples, bananas, and walnuts, whole period (4 days) .....	33.98	19.30	8.63	+ 6.05
	Average for 1 day .....	8.49	4.82	2.16	+ 1.51
402	Apples, bananas, and almonds, whole period (4 days) .....	45.60	19.97	9.15	+16.48
	Average for 1 day .....	11.40	4.99	2.29	+ 4.12
404	Apples, bananas, and Brazil nuts, whole period (4 days) .....	25.40	22.29	6.27	- 3.16
	Average for 1 day .....	6.35	5.57	1.57	- .79
407	Apples, bananas, and pecans, whole period (4 days) .....	22.62	29.02	6.91	-13.31
	Average for 1 day .....	5.66	7.25	1.73	- 3.33
408	Apples, bananas, pecans, and granose, whole period (4 days) .....	29.68	31.43	10.64	-12.39
	Average for 1 day .....	7.42	7.86	2.66	- 3.10
409	Oranges, bananas, and pecans, whole period (4 days) .....	25.02	24.46	7.33	- 6.77
	Average for 1 day .....	6.25	6.11	1.83	- 1.69
410	Oranges, bananas, pecans, and granose, whole period (4 days) .....	31.22	31.63	9.40	- 9.81
	Average for 1 day .....	7.81	7.91	2.35	- 2.45
411	Oranges, prunes, and walnuts, whole period (3 days) .....	29.60	14.37	4.93	+10.30
	Average for 1 day .....	9.87	4.79	1.64	+ 3.43
412	Dates, olives, and walnuts, whole period (4 days) .....	21.87	19.15	8.78	- 6.06
	Average for 1 day .....	5.47	4.79	2.20	- 1.52
413	Dates, olives, and almonds, whole period (4 days) .....	23.94	23.97	8.19	- 8.22
	Average for 1 day .....	5.98	5.99	2.05	- 2.06
414	Dates, olives, almonds, and granose, whole period (4 days) .....	29.64	22.56	8.96	- 1.88
	Average for 1 day .....	7.41	5.64	2.24	- .47
415	Gofio (prepared cereal), whole period (3 days) .....	26.87	17.26	6.52	+ 3.09
	Average for 1 day .....	8.95	5.75	2.17	+ 1.03

It appears that the minimum amount of food eaten per day was during experiment No. 391, in which the diet consisted exclusively of bananas. This furnished only 22 grams of protein and 1,160 calories of energy, and while, as was to be expected, there was a loss of body protein, it is somewhat surprising that the subject did not lose weight. This is presumably due to the large quantity of water ingested with the bananas. From Table 47 it is seen that the coefficients of digestibility in this experiment, for all the nutrients except fat, are very satisfactory and in each case considerably above the average for all the tests with the subject. The body utilized over 90 per cent of the energy supplied by the diet, the corresponding average for the 16 experiments being 84.76 per cent. This can perhaps be accounted for on the supposition that the body, having so little nitrogenous material at its disposal, was compelled to use all supplied to the utmost advantage, or the subject may have had some idiosyncrasy favorable to the digestion of bananas.

The maximum food consumption during this series of experiments is noted for experiment No. 402, with a diet of apples, bananas, and almonds. During this experiment about three and a half times as much protein and energy were consumed as in experiment No. 391. In this case the maximum average daily gain of protein (4.13 grams) was also observed. It is of interest to note that during the two experiments, representing, respectively, the maximum and minimum amounts of food eaten, the body weight remained constant. The fact that 79.9 per cent of the protein was digested and 88.15 per cent of the energy was available indicates the high nutritive value of the combination of apples, bananas, and almonds.

The high digestibility of the almond, as compared with walnuts, Brazil nuts, and pecans, is shown by a comparison of the results of experiments Nos. 399 and 402 with those of experiments Nos. 400, 404, and 407.

The coefficients of digestibility in experiment No. 397, where walnuts were used, are all lower than in No. 399, where almonds were eaten in place of walnuts. This is especially true of the protein and energy, the percentages being 62.56 and 78.87, and 74.48 and 86.17, respectively. In the other four experiments the combination of apples and bananas remained constant, while a change was made in the variety of the nut. In No. 402, where almonds were eaten, the coefficients are the highest, and in No. 407, in which pecans were used, the coefficients are the lowest. A reference to Table 46 shows that during experiment No. 407 the amount of protein furnished by the diet was but 35.36 grams per day, the lowest reported for any of the experiments in question. Again it is of interest to note that, with the exception of experiment No. 400, the coefficient of digestibility of protein varied directly with the amount consumed per day during the four experimental periods.



The great difference between the quantities of food eaten during these four experiments may have arisen from several causes. It may be that the almonds were more palatable, and that this accounted for the increased consumption of food in No. 402; or possibly the diet became too monotonous during the fourth period (experiment No. 407), and therefore less food was eaten. On the other hand, it will be observed that the maximum amount of food ingested was not with experiment No. 400, the first of the series with apples and bananas with nuts, but during experiment No. 402, the second of the series, and that in the third experiment, No. 404, when Brazil nuts were used, there was a sudden drop of over 45 per cent in the protein and nearly 35 per cent in the energy in the diet. A comparison of experiments Nos. 412 and 413, in which there was an entirely different combination of fruits, also emphasizes the high digestibility of the almond. Notwithstanding the fact that almonds were used in experiment No. 413, thus putting it at a disadvantage as regards the monotony of the diet, the coefficients of digestibility of all the nutrients and energy are appreciably higher than in experiment No. 412. In view of these data the conclusion seems warranted that almonds possess a higher coefficient of digestibility, at least for this subject, than do either walnuts, Brazil nuts, or pecans.

The reason of the low coefficient of digestibility for protein in experiment No. 392, as noted earlier, is that the almonds eaten were ground to a paste and in this form did not agree with the subject, but caused indigestion. In view of this fact almonds were not compared with the other nuts in the foregoing discussion.

It appears from the tables that the diet which resulted in the highest coefficients of digestibility furnished next to the highest protein and energy per day, and induced next to the highest net increase in body protein, was a combination of oranges, prunes, and walnuts. This dietary, however, was so laxative for the subject that the experiment had to be terminated at the end of the third day.

The diet consisting of dates, olives, and walnuts, used in experiment No. 412, yielded the lowest coefficients of digestibility.

While it appears from Table 47 that a combination of apples, bananas, and pecans (experiment No. 407) is as digestible as a diet of oranges, bananas, and pecans (experiment No. 409), a reference to Table 48, showing the income and outgo of nitrogen, indicates that in the latter case the loss of body protein is only about one-half that noted for the former. But it must be remembered that in experiment No. 409 about 25 per cent more pecans were eaten, thus supplying a notable increase in the daily protein as compared with experiment No. 407.

Chemical analysis has shown that the apple contains very little protein, and a study of the data in Table 47 would seem to indicate that,



for this subject at least, the quantity present has a very low coefficient of digestibility. The coefficient for the protein in a diet of bananas and walnuts was 75.85 per cent. When apples were substituted for bananas the coefficient was 62.56 per cent, and again when apples and bananas were used in combination with walnuts (experiment No. 400) the coefficient was 74.63.

Comparing experiments Nos. 407 and 408 and Nos. 409 and 410 it would seem that the addition of granose to the diet lowered the coefficients of digestibility of all the nutrients and the coefficient of availability of the energy. In view of the relatively high coefficients of digestibility of foods like granose it is more than likely that the lower values observed were due to the granose interfering with the digestion of the nuts.

The coefficients of availability of the gofio used in experiment No. 415 compared very favorably with the averages obtained for the 16 experiments with fruit and nuts with the same subject given in Table 47.

Considering all the experiments, the average coefficient of digestibility of fat, 86.16 per cent, implies that the fat of the nuts possesses a high nutritive value. This average would be materially increased if experiment No. 391, showing the minimum 18.96 per cent, were not included in the calculation. The maximum digestibility, 91.84 per cent, was noted for experiment No. 402, in which the diet consisted of bananas, apples, and almonds.

The results given in Table 47 indicate that in every experiment the sugar and starch of the fruits and nuts were very well assimilated. The minimum, maximum, and average coefficients of digestibility for sugar, starch, etc., are 89.15 per cent, 97.48 per cent, and 93.73 per cent, respectively. The digestibility of the crude fiber ranged from 19.71 per cent in experiment No. 388 to 89.41 per cent in experiment No. 411, and was on the average 74.36 per cent. The highest coefficient of digestibility for the mineral matter (78.38 per cent) was noted in experiment No. 391, and the lowest (34.51 per cent) in experiment No. 404.

As may be seen by reference to Table 48 there was a loss of body protein in eleven of the sixteen experiments. The average daily loss of nitrogen ranged from 0.04 gram (0.25 gram protein) in experiment No. 397 to 3.30 grams (20.63 grams protein) in experiment No. 407. The maximum gain (4.12 grams) is reported for experiment No. 402 and the minimum gain, 0.21 gram nitrogen, in experiment No. 399. It thus appears that in order to attain nitrogen equilibrium this subject required about 8 grams of nitrogen (50 grams protein) per day, when the daily food furnished not far from 1,800 calories of energy. It must be remembered, however, that much depends on the source and digestibility of the protein. In experiment No. 408 the daily diet of

apples, bananas, pecans, and granose furnished 7.42 grams of nitrogen, which evidently was insufficient, as there was recorded an average daily loss of 3.1 grams nitrogen. Again, in experiment No. 407, with a diet of the same fruit and nuts but no granose, the daily income of nitrogen was 5.68 grams and the loss 3.3 grams.

### EXPERIMENTS WITH A. V. AND J. E. R.

The digestion experiments made with the subjects A. V. and J. E. R. follow. Both were young men, university students, and in good health. Neither subject was used to a vegetarian or fruitarian diet, though A. V. had been experimenting with such diets for a number of years.

#### DIGESTION EXPERIMENT NO. 416.

*Kind of food.*—Bananas, oranges, almonds.

*Subject.*—A. V.

*Weight (without clothes).*—At the beginning of the experiment 68.9 kilograms (152 pounds), and at the close 69.4 kilograms (153 pounds).

*Duration.*—Four days, with twelve meals, beginning with breakfast, May 5, 1902.

TABLE 49.—*Results of digestion experiment No. 416.*

Sample No.	Kind of food.	Weight of material.	Total organic matter.	Nitrogen.	Protein.	Fat.	Carbohydrates.		Ash.	Heat of combustion.
							Sugar, starch, etc.	Fiber.		
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
212a	Bananas.....	7,081	984.31	11.44	71.52	10.62	878.80	23.37	36.11	4,168
236a	Oranges.....	10,474	976.30	17.43	108.94	11.52	810.80	45.04	49.23	4,181
249	Almonds.....	990	918.73	27.37	171.07	537.60	184.52	25.54	27.52	6,821
	Total.....	18,545	2,879.34	56.24	351.53	559.74	1,874.12	93.95	112.86	15,170
126a	Feces (water-free).....	386.50	333.99	14.91	93.16	91.45	127.78	21.60	52.51	2,227
	Amount digested.....	2,539.35	41.33	258.37	468.29	1,746.34	72.35	60.35	12,943	
	Per cent digested.....	88.20	73.51	73.51	83.64	93.18	77.02	58.47	85.26	
	Energy of urine.....									323
	Energy of food oxidized in the body.....									12,620
	Per cent of energy utilized.....									83.19

During this experiment the subject eliminated 6,191 grams urine, containing 0.69 per cent or 42.71 grams nitrogen. The average nitrogen balance per day was therefore as follows: Income in food 14.06 grams; outgo in urine 10.68 grams, and in feces 3.73 grams; indicating a loss of 0.35 gram nitrogen, corresponding to 2.19 grams protein.

Owing to the larger consumption of nuts the protein supplied per day during this test was 30 per cent more than the daily protein average for the same subject in dietary No. 363 (p. 29). The fuel values for the two studies (3,305 and 3,155 calories, respectively) show

a much closer agreement. In spite, however, of the comparatively larger quantity of protein consumed there was a slight loss of nitrogen, thus implying that this subject required between 15 and 16 grams per day, with about 3,300 calories of energy, in order to attain nitrogen equilibrium. The data recorded indicate that the body assimilated the food very thoroughly.

# DIGESTION EXPERIMENT NO. 417.

*Kind of food.*—Bananas, dates, walnuts, with a small quantity of sugar.

*Subject.*—J. E. R.

*Weight (with clothes).*—At the beginning of the experiment 76.7 kilograms (169 pounds), and at the close 75.3 kilograms (166 pounds).

*Duration.*—Four days, with twelve meals, beginning with breakfast May 6, 1902.

TABLE 50.—Results of digestion experiment No. 417.

Sample No.	Kind of food.	Weight of material.	Total organic matter.	Nitrogen.	Protein.	Fat.	Carbohydrates.		Ash.	Heat of combustion.
							Sugar, starch, etc.	Fiber.		
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
212a	Bananas.....	3,005	417.68	4.86	30.35	4.51	372.90	9.92	15.24	1,768
37	Dates.....	964	544.66	4.16	26.03	2.89	495.50	20.24	12.53	2,250
223a	Walnuts.....	1,290	480.71	20.08	125.50	321.41	24.25	9.55	9.80	3,722
46	Sugar.....	258	258.00	.....	.....	.....	258.00	.....	.....	989
	Total.....	5,517	1,701.05	29.10	181.88	328.81	1,150.65	39.71	37.57	8,729
130a	Feces (water-free)	228.67	205.73	8.86	55.36	79.47	62.56	8.34	22.94	1,445
	Amount digested	.....	1,495.32	20.24	126.52	249.34	1,088.09	31.37	14.63	7,284
	Per cent digested	.....	87.90	69.56	69.56	75.83	94.58	79.00	38.94	83.44
	Energy of urine	.....	.....	.....	.....	.....	.....	.....	.....	158
	Energy of food oxidized in the body	.....	.....	.....	.....	.....	.....	.....	.....	7,126
	Per cent of energy utilized	.....	.....	.....	.....	.....	.....	.....	.....	81.64

During this experiment the subject eliminated 2,225 grams urine, containing 1.40 per cent or 27.54 grams nitrogen. The average nitrogen balance per day was therefore as follows: Income in food 7.28 grams; outgo in urine 6.89 grams, and in feces 2.21 grams; indicating a loss of 1.82 grams nitrogen, corresponding to 11.38 grams protein.

This experiment was preceded by a preliminary period of three days, during which the subject followed the same diet as in the digestion experiment. During this time there was no appreciable loss of weight. The subject had to perform an unusual amount of hard work during the test proper, which accounts, in part at least, for the loss of weight experienced. Furthermore, he drank very little water.

## DIGESTION EXPERIMENT NO. 418.

*Kind of food.*—Bananas, oranges, walnuts, with a small quantity of sugar.

*Subject.*—J. E. R.

*Weight (with clothes).*—At the beginning of the experiment 75.3 kilograms (166 pounds), and at the close 75.9 kilograms (167.5 pounds).

*Duration.*—Four days, with twelve meals, beginning with breakfast May 13, 1902.

TABLE 51.—Results of digestion experiment No. 418.

Sample No.	Kind of food.	Weight of material.	Total organic matter.	Nitrogen.	Protein.	Fat.	Carbohydrates.		Ash.	Heat of combustion.
							Sugar, starch, etc.	Fiber.		
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
212a	Bananas.....	2,438	338.88	3.93	24.62	3.66	302.55	8.05	12.43	1,434
238a	Oranges, navel...	4,054	387.93	6.09	38.11	5.27	326.70	17.85	19.05	1,663
223a	Walnuts.....	1,304	486.05	20.30	126.89	324.99	24.52	9.65	9.91	3,784
46	Sugar.....	190	190.00	.....	.....	.....	190.00	.....	.....	751
	Total.....	7,986	1,402.86	30.32	189.62	333.92	843.77	35.55	41.39	7,632
134a	Feces (water-free)	232.13	205.48	8.71	54.41	85.93	55.86	9.28	26.64	1,479
	Amount digested.....	1,197.38	21.61	135.21	247.99	787.91	26.27	14.75	6,153	
	Per cent digested.....	85.35	71.28	71.31	74.26	93.40	73.90	35.64	80.63	169
	Energy of urine.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Energy of food oxidized in the body.....	.....	.....	.....	.....	.....	.....	.....	.....	5,984
	Percent of energy utilized.....	.....	.....	.....	.....	.....	.....	.....	.....	78.41

During this experiment the subject eliminated 1,657 grams urine, containing 1.76 per cent or 29.16 grams nitrogen. The average nitrogen balance per day was therefore as follows: Income in food 7.58 grams; outgo in urine 7.29 grams, and in feces 2.18 grams; indicating a loss of 1.89 grams nitrogen, corresponding to 11.81 grams protein.

The subject considered the diet of bananas, oranges, and walnuts more palatable than the previous one of bananas, dates, and walnuts, but a comparison of the results of the two tests does not indicate that the amount of nutrients eaten or assimilated was increased.

In dietary study No. 362, p. 27, with the same subject, the daily diet furnished 85 grams protein and 2,937 calories of energy, amounts which are far in excess of the average values for the two experiments just reported. In no case was the amount to be eaten limited, but in the digestion experiments the diet was limited to two kinds of fruit and one of nuts, while in the dietary study the variety of fruits and nuts was larger, as may be seen by reference to Table 12.

Considering this and the preceding experiment, the average daily income of protein, 46.44 grams, was evidently below the limit of tolerance for this subject. In both experiments a loss occurred which was almost identical. It would appear, then, that the nitrogen limit of this subject was about 10 grams per day, when the diet furnished about 1,900 calories of energy.



## GENERAL SUMMARY OF DIGESTION EXPERIMENTS.

It is of interest to compare the average amount of nutrients digested by the different subjects, as is done in Table 52, which also includes the average results of a large number of tests with young men on a diet consisting of ordinary food materials, but in many cases supplying a large proportion of fat or carbohydrates as compared with protein, and of a large number of tests with young men on an ordinary mixed diet.

TABLE 52.—*Summary of digestion experiments.*

Subjects and number of experiments.	Total organic matter.	Protein.	Fat.	Carbohydrates.		Ash.	Energy available.
				Sugar, starch, etc.	Fiber.		
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
Subject C. P. H., 16 experiments .....	88.71	71.76	86.16	93.70	74.60	54.02	84.76
Subject W. S. M., 11 experiments .....	92.56	79.96	88.61	96.83	81.86	58.47	88.78
Subject J. E. R., 2 experiments .....	86.74	70.44	75.05	94.06	76.58	37.21	80.14
Subject A. V., 1 experiment .....	88.20	73.51	83.64	93.18	77.02	53.47	83.19
Average, 30 experiments .....	90.26	75.30	86.43	95.10	78.54	54.76	86.13
Average of 50 experiments with young men on diet of ordinary food materials supplying in many cases large proportions of fat or carbohydrates <sup>a</sup> .....		90.80	95.30	97.60			
Average of 93 experiments with young men on ordinary diet <sup>b</sup> .....		93.30	95.00	97.70			

<sup>a</sup> Conn. (Storrs) Station Rpt. 1901, p. 235.

<sup>b</sup> Conn. (Storrs) Station Rpt. 1899, p. 87.

The lowest coefficients of digestibility were found with subject J. E. R., and the highest with subject W. S. M. The high coefficients noted for the latter subject may be accounted for in part by the addition to the diet of small quantities of relishes, such as olive oil, tomatoes, and olives, which possibly increased the flow of digestive juices, or may be due to the fact that he had been longer accustomed to the diet.

As will be seen from the figures in the above table, the average coefficients of digestibility of carbohydrates obtained for the fruits and nuts compare favorably with those quoted for a mixed diet.

While coefficients of digestibility can easily be calculated from the foregoing data for the several fruits and nuts alone, it seems unwise to do so at present. Later, when more data have accumulated, particularly regarding the digestibility of fruits and nuts in a mixed diet, it should be possible to obtain coefficients of digestibility which will stand the test of criticism and be of practical use in determining the real nutritive value of dietaries containing such foods.

## INCOME AND OUTGO OF NITROGEN.

As will be seen by reference to the tables reporting the results of the individual tests, there was considerable variation in the income and outgo of nitrogen with the different subjects. Table 53 summarizes the data on this topic, recording the tests in which maximum and minimum gain or loss was noted, and also shows the energy in the several cases.

TABLE 53.—*Income and outgo of nitrogen—Summary of daily maxima and minima gains and losses.*

Experiment No.		Nitrogen.				Energy of daily diet.
		In food.	In urine.	In feces.	Gain (+) or loss (-).	
	SUBJECT C. P. H. (16 EXPERIMENTS).					
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Calories.</i>
407	Maximum loss .....	5.66	7.25	1.73	-3.33	3,279
397	Minimum loss .....	7.18	4.53	2.69	- .04	.....
402	Maximum gain .....	11.40	4.99	2.29	+4.12	2,768
399	Minimum gain .....	7.14	5.11	1.82	+ .21	1,712
	SUBJECT W. S. M. (11 EXPERIMENTS).					
388	Maximum loss .....	2.20	4.67	1.22	-3.69	.....
405	Minimum loss .....	7.60	5.84	1.81	- .05	2,870
394	Maximum gain .....	15.00	7.40	1.98	+5.62	.....
393	Minimum gain .....	8.62	5.59	1.74	+1.29	.....
	SUBJECT J. E. R. (2 EXPERIMENTS).					
418	Maximum loss .....	7.58	7.29	2.18	-1.89	2,544
417	Minimum loss .....	7.28	6.89	2.21	-1.82	2,910
	SUBJECT A. V. (1 EXPERIMENT).					
416	Loss .....	14.06	10.68	3.73	- .35	3,793

As may be seen by reference to the table, the daily excretion of nitrogen in the urine in these experiments with fruitarian or vegetarian diets was small. It must be remembered in this connection that under ordinary conditions the daily excretion of nitrogen in the urine depends mainly on the amount of nitrogen ingested in the food and not on the nature of the diet, and in these tests the amount of protein in the food eaten per day was small.

It appears that for subjects W. S. M. and C. P. H. the minimum daily losses (0.04 gram and 0.05 gram) are reported for the experiments where the nitrogen ingested is 7.18 grams and 7.60 grams, respectively, thus implying that to attain nitrogen equilibrium, with the same amount of energy as was furnished by the diet studied, these subjects should receive at least 8 grams of nitrogen per day. The loss of nearly 2 grams of nitrogen per day, experienced by subject J. E. R. in the two experiments with an income of 7 to 8 grams per day, would seem to indicate that, at least in a fruitarian diet with the same amount of energy, the nitrogen required daily would be about 10 grams.

The comparatively large daily income of nitrogen (14.06 grams) reported for subject A. V. was insufficient for the maintenance of his nitrogen equilibrium, although it was practically twice as great as that

(7.14 grams) of subject C. P. H. in experiment No. 399, where a slight gain of nitrogen was noted.

It is true that the above results are not in harmony with those observed with the ordinary mixed diet, yet at the same time they are not unique. Voit, Rumpf, and Schumm, and Albu, as already pointed out (p. 30), have reported experiments with vegetarians whose average daily income of nitrogen was far below the tentative standards but yet was found to be sufficient either to just maintain the nitrogen equilibrium or to cause a slight gain. Hirschfeld,<sup>a</sup> Kumagawa,<sup>b</sup> Klemperer,<sup>c</sup> Peschel,<sup>d</sup> Caspari,<sup>e</sup> Siven,<sup>f</sup> Neumann,<sup>g</sup> and others have conducted metabolism experiments with subjects on mixed diets furnishing much less nitrogen than the commonly accepted standards call for and have found that the nitrogen equilibrium can be maintained with small amounts of protein in the food.

As regards the experiments quoted, it will be seen that the minimum amount of protein necessary to maintain the nitrogen balance varies between wide limits. Klemperer reports the minimum amount 33 grams of daily protein and the writer the maximum 87.9 grams. In the former case a gain is noted and in the latter a loss. It thus appears that with one subject, weighing 141 pounds, 33 grams protein and 5,018 calories were more than sufficient to attain nitrogen equilibrium; another subject, A. V., weighing 150 pounds, with a diet furnishing 87.9 grams protein and 3,155 calories, suffered a slight loss of nitrogen. These findings serve to emphasize the conclusion of Caspari that the minimum amount of daily protein required varies with the individual and may even vary with the same individual at different times.

It must be remembered that although a gain of nitrogen was reported by Albu when the daily diet supplied only 34 grams protein and 1,400 calories the subject was a very small woman, weighing but 83 pounds. Siven<sup>h</sup> brings out one point in his conclusions, in full accord with the results of the present investigation and which should serve as a warning to anyone contemplating any appreciable decrease in the protein of the daily diet, namely, that when the protein of the food is increased after the body has suffered a loss of nitrogen, there is at once an effort to attain nitrogen equilibrium, and it appears that any gain of nitrogenous body material is a comparatively slow process. This apparently indicates that the living substance must be slowly formed from the protein furnished by the diet.

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<sup>a</sup>Arch. Physiol. [Pflüger], 41 (1887), p. 533.

<sup>b</sup>Arch. Path. Anat. u. Physiol. [Virchow], 116 (1889), p. 370.

<sup>c</sup>Arch. Path. Anat. u. Physiol. [Virchow], 116 (1889), p. 362.

<sup>d</sup>Der Eiweissbedarf des gesunden Menschen, Inaug. Diss., Berlin, 1890.

<sup>e</sup>Arch. Anat. u. Physiol., Physiol. Abt., 1901, p. 323.

<sup>f</sup>Skand. Arch. Physiol., 11 (1901), p. 308.

<sup>g</sup>Arch. Hyg., 45 (1902), p. 1.

<sup>h</sup>Skand. Arch. Physiol., 11 (1901), p. 330.

Even if it could be proved by a large number of experiments that nitrogen equilibrium can be maintained on a small amount of protein, it would still be a great question whether or not it would be wise to do so. There must certainly be a constant effort on the part of the human organism to attain this condition, and with a low protein supply it might be forced to do so under conditions of strain. In such a case the bad results might be slow in manifesting themselves, but might also be serious and lasting. It has also been suggested that when living at a fairly high protein level the body is more resistant to disease and other strains than when the protein level is low.

#### AMOUNT OF FECES ON A FRUITARIAN DIET.

It is interesting in this connection to compare the composition of the water-free feces from the digestion experiments here recorded with similar data from other sources, as is done in the following table:

TABLE 54.—*Comparison of composition of water-free feces.*

Whence obtained.	Nature of diet.	Weight of feces.	Nitro- gen.	Pro- tein.	Fat.	Car- bohy- drates.	Ash.	Heat of combustion per gram.
		<i>Grams.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Calories.</i>
Average 11 experiments; subject, W. S. M.	Fruitarian.....	44.52	4.23	26.43	28.09	33.69	11.80	5,732
Average 16 experiments; subject, C. P. H.	.....do.....	49.89	4.09	25.56	24.61	36.48	13.35	5,680
Average 2 experiments; subject, J. E. R.	.....do.....	57.60	3.84	23.96	35.23	30.04	10.77	6,328
Average 1 experiment; subject, A. V.	.....do.....	96.63	3.87	24.18	23.63	38.40	13.79	5,783
Average of above 30 ex- periments.	.....do.....	48.30	4.14	25.88	26.05	35.53	12.54	5,716
Average 12 experiments, <i>a</i> .	Bread and milk ..	65.3	5.22	31.82	15.33	33.04	18.98	5,479
Average 14 experiments, <i>b</i> .	Mixed .....	119.0	4.87	30.42	24.54	21.75	23.29	<i>c</i> 4,316
Average 10 experiments, <i>d</i> .	Bread and milk ..	96.4	3.02	18.89	13.94	37.42	29.75	5,568

*a* U. S. Dept. Agr., Office of Experiment Stations Bul. 85.

*b* U. S. Dept. Agr., Office of Experiment Stations Bul. 117.

*c* Heat of combustion calculated.

*d* U. S. Dept. Agr., Office of Experiment Stations Bul. 121.

An examination of the above table shows that the average amount, 49.38 grams per day, of water-free feces from the 30 digestion experiments with fruitarian diet is much less than the corresponding amount reported for either bread and milk or mixed diet. It is also considerably below the average weights, 71.16 grams and 56 grams, of water-free feces from digestion experiments with vegetarians reported by Voit<sup>a</sup> and Albu<sup>b</sup>, respectively.

It will be observed that the feces from the experiments with mixed diet and the average from the 12 experiments with bread and milk diet are much larger in amount and contain more protein than the average of the feces from the fruitarian experiments. The latter, however, contain more fat and carbohydrates.

<sup>a</sup> Ztschr. Biol., 25 (1889), p. 234.

<sup>b</sup> Ztschr. Klin. Med. [Berlin], 43 (1901), p. 75.



It thus appears from the table that the feces from the digestion experiments made with fruitarians here reported are not excessive in amount, as has usually been found to be the case with experiments with a vegetarian diet containing very little or no fruit.

### METABOLIC NITROGEN IN THE FECES.

When considering the digestibility of any article of food it is quite important that allowance be made for the so-called metabolic products.<sup>a</sup> At present there is no accurate method in vogue for the separation of the metabolic nitrogen from the nitrogen belonging to the undigested residue of the food in question, which is necessary in determining the true or absolute digestibility. The coefficients of digestibility of protein, therefore, which are obtained without taking into account the metabolic nitrogen, are lower more or less than they should be.

If, however, the digestibility of any food or combination of foods is looked at in another light, the matter appears somewhat differently. Whether a certain amount of nitrogen is lost to the body through the undigested residue of the food, or whether it is lost through the metabolic products, makes practically no difference as regards the net income of nitrogen from the food: or, in other words, the real value of that food or food combination as a source of nitrogen to be utilized for other functions of the body than digestion.

The metabolic nitrogen in the feces in nineteen of the experiments was determined, the method followed being the same as that previously used;<sup>b</sup> that is, the feces were treated successively with hot ether, hot alcohol, hot water, and cold limewater, reagents which experiment has shown dissolve the metabolic products present.

The results of these analyses are given in Table 55.

TABLE 55.—*Total nitrogen in feces and nitrogen corrected for metabolic products.*

Ex- per- iment No.	Kind of food.	Duration of test.	Amount of feces (water- free).	Nitrogen—		
				In un- treated feces.	In feces treated with re- agents.	In meta- bolic prod- ucts.
	SUBJECT C. P. H.					
		<i>Days.</i>	<i>Grams.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
391	Bananas, 1st day.....		20.30	4.61	3.20	1.41
	Bananas, 2d day.....		17.60	4.15	3.65	.50
	Bananas, 3d day.....		19.50	4.40	3.69	.71
	For whole period.....	3	57.40	4.41	3.50	.91
392	Bananas and almonds, 1st day.....		54.00	4.72	3.30	1.42
	Bananas and almonds, 2d day.....		2.79	4.94	3.59	1.35
	Bananas and almonds, 3d day.....		30.00	4.42	3.52	.90
	Bananas and almonds, 4th day.....		85.24	3.99	3.29	.70
	For whole period.....	4	172.03	4.31	3.34	.97

<sup>a</sup>See discussion of the subject in U. S. Dept. Agr., Office of Experiment Stations Buls. 85 and 107.

<sup>b</sup>U. S. Dept. of Agr., Office of Experiment Stations Bul. 107.

TABLE 55.—*Total nitrogen in feces and nitrogen corrected for metabolic products—C't'd.*

Ex- peri- ment No.	Kind of food.	Duration of test.	Amount of feces (water- free).	Nitrogen—		
				In un- treated feces.	In feces treated with re- agents.	In meta- bolic prod- ucts.
	SUBJECT C. P. H.—continued.	<i>Days.</i>	<i>Grams.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
395	Bananas and walnuts, 1st day .....		29.38	3.98	2.78	1.20
	Bananas and walnuts, 2d day .....		38.49	4.00	2.92	1.08
	Bananas and walnuts, 3d day .....		65.78	3.66	2.88	.78
	Bananas and walnuts, 4th day .....		30.41	4.08	3.30	.78
	For whole period .....	4	164.06	3.88	2.95	.93
397	Apples and walnuts, 1st day .....		69.86	4.78	3.19	1.59
	Apples and walnuts, 2d day .....		79.52	5.22	3.53	1.69
	Apples and walnuts, 3d day .....		9.10	5.92	4.22	1.70
	Apples and walnuts, 4th day .....		56.98	4.77	3.34	1.43
	For whole period .....	4	215.46	4.99	3.40	1.59
399	Apples and almonds, 1st day .....		38.99	4.69	3.69	1.00
	Apples and almonds, 2d day .....		43.52	4.81	3.59	1.22
	Apples and almonds, 3d day .....		35.48	4.49	3.69	.80
	Apples and almonds, 4th day .....		44.49	4.00	3.15	.85
	For whole period .....	4	162.48	4.49	3.52	.97
400	Apples, bananas, and walnuts, 1st day .....		37.79	5.49	4.05	1.44
	Apples, bananas, and walnuts, 2d day .....		83.58	4.60	3.31	1.29
	Apples, bananas, and walnuts, 3d day .....		26.20	5.16	3.73	1.43
	Apples, bananas, and walnuts, 4th day .....		28.90	4.70	3.33	1.37
	For whole period .....	4	176.47	4.89	3.53	1.36
402	Apples, bananas, and almonds, 1st day .....		56.99	4.96	3.81	1.15
	Apples, bananas, and almonds, 2d day .....		52.98	4.48	3.47	1.01
	Apples, bananas, and almonds, 3d day .....		55.98	4.61	3.53	1.08
	Apples, bananas, and almonds, 4th day .....		59.40	3.99	2.99	1.00
	For whole period .....	4	205.35	4.46	3.41	1.05
404	Apples, bananas, and Brazil nuts, 1st day .....		90.82	3.17	2.61	.56
	Apples, bananas, and Brazil nuts, 2d day .....		30.79	2.80	2.24	.56
	Apples, bananas, and Brazil nuts, 3d day .....		37.40	4.13	3.35	.78
	Apples, bananas, and Brazil nuts, 4th day .....		23.30	4.20	3.48	.72
	For whole period .....	4	182.31	3.44	2.81	.63
	Average of experiments .....		166.90	4.36	3.31	1.05
	SUBJECT W. S. M.					
388	Grapes, assorted, 1st day .....		28.85	3.79	2.92	.87
	Grapes, assorted, 2d day .....		15.00	4.05	3.23	.82
	Grapes, assorted, 3d day .....		25.40	4.50	2.99	1.51
	Grapes, assorted, 4th day .....		58.50	3.49	2.49	1.00
	For whole period .....	4	127.75	3.82	2.77	1.05
389	Grapes and Brazil nuts, 1st day .....		57.40	3.88	3.08	.80
	Grapes and Brazil nuts, 2d day .....		40.28	3.09	2.01	1.08
	Grapes and Brazil nuts, 3d day .....		20.82	2.89	2.04	.85
	Grapes and Brazil nuts, 4th day .....		34.34	3.81	2.65	1.16
	For whole period .....	4	152.84	3.53	2.56	.97
390	Grapes, Brazil nuts, granose, 1st day ..		31.81	4.20	3.19	1.01
	Grapes, Brazil nuts, granose, 2d day ..		63.06	3.57	2.61	.96
	Grapes, Brazil nuts, granose, 3d day ..		30.54	3.55	2.66	.89
	Grapes, Brazil nuts, granose, 4th day ..		43.10	3.56	2.55	1.01
	For whole period .....	4	168.51	3.68	2.72	.96

TABLE 55.—*Total nitrogen in feces and nitrogen corrected for metabolic products.*—C't'd.

Ex- peri- ment No.	Kind of food.	Dura- tion of test.	Amount of feces (water- free).	Nitrogen—		
				In un- treated feces.	In feces treated with re- agents.	In meta- bolic prod- ucts.
	SUBJECT W. S. M.—continued.					
		Days.	Grams.	Per cent.	Per cent.	Per cent.
393	Grapes, walnuts, granose, 1st day .....		88.50	4.43	3.04	1.39
	Grapes, walnuts, granose, 2d day .....		11.20	5.17	4.03	1.14
	Grapes, walnuts, granose, 3d day .....		34.78	4.72	3.37	1.35
	Grapes, walnuts, granose, 4th day .....		15.75	5.32	3.74	1.58
	For whole period .....	4	150.23	4.65	3.26	1.39
394	Persimmons and peanuts, 1st day .....		60.37	3.82	2.44	1.38
	Persimmons and peanuts, 2d day .....		53.50	3.02	2.23	.79
	Persimmons and peanuts, 3d day .....		85.00	3.39	2.43	.96
	Persimmons and peanuts, 4th day .....		34.00	3.29	2.32	.97
	For whole period .....	4	232.96	3.41	2.37	1.04
396	Pears, walnuts, milk (227 grams), granose (113 grams), 1st day .....		53.30	4.01	2.88	1.13
	Pears, walnuts, milk (227 grams), granose (113 grams), 2d day .....		58.80	3.78	2.68	1.10
	Pears, walnuts, milk (227 grams), granose (113 grams), 3d day .....		24.20	4.18	3.05	1.13
	Pears, walnuts, milk (227 grams), granose (113 grams), 4th day .....		48.18	3.98	2.39	1.59
	For whole period .....	4	184.48	3.95	2.71	1.24
398	Pears and cocoanuts, 1st day .....		39.59	3.49	2.40	1.09
	Pears and cocoanuts, 2d day .....		33.69	3.48	2.23	1.25
	Pears and cocoanuts, 3d day .....		49.79	2.93	1.76	1.17
	Pears and cocoanuts, 4th day .....		52.38	3.12	2.05	1.07
	For whole period .....	4	175.45	3.22	2.08	1.14
401	Dried figs, apples, and walnuts, 1st day .....		53.80	5.27	3.44	1.83
	Dried figs, apples, and walnuts, 2d day .....		55.28	4.88	3.56	1.32
	Dried figs, apples, and walnuts, 3d day .....		41.17	5.48	3.43	2.05
	Dried figs, apples, and walnuts, 4th day .....		70.98	5.94	3.59	2.35
	For whole period .....	4	221.23	5.43	3.52	1.91
403	Apples, dates, and peanuts, 1st day .....		69.70	5.27	3.28	1.99
	Apples, dates, and peanuts, 2d day .....		68.70	4.55	2.42	2.13
	Apples, dates, and peanuts, 3d day .....		47.55	5.29	2.50	2.79
	Apples, dates, and peanuts, 4th day .....		34.60	4.35	2.31	2.04
	For whole period .....	4	220.55	4.91	2.69	2.22
405	Apples, dates, and pecans, 1st day .....		47.07	4.33	3.18	1.15
	Apples, dates, and pecans, 2d day .....		47.49	4.58	3.81	.77
	Apples, dates, and pecans, 3d day .....		30.00	4.97	3.59	1.38
	Apples, dates, and pecans, 4th day .....		35.20	4.40	3.38	1.02
	For whole period .....	4	159.76	4.55	3.49	1.06
406	Apples, raisins, and walnuts, 1st day .....		20.49	4.89	3.25	1.64
	Apples, raisins, and walnuts, 2d day .....		64.98	5.11	3.23	1.88
	Apples, raisins, and walnuts, 3d day .....		29.40	4.93	3.81	1.12
	Apples, raisins, and walnuts, 4th day .....		55.50	5.33	3.15	2.18
	For whole period .....	4	165.37	5.12	3.31	1.81
	Average of experiments .....		178.10	4.21	2.86	1.35

As will be seen by the figures in the table, the metabolic nitrogen is equal to the total nitrogen in the untreated feces less the amount remaining in the feces after treatment with the reagents; that is, it is equivalent to the amount dissolved out by the reagents. In a previous experiment<sup>a</sup> it was found that the solvents above mentioned dissolved 42 per cent of the total nitrogen present.

<sup>a</sup> U. S. Dept. Agr., Office of Experiment Stations Bul. 107.

The average amount of metabolic nitrogen in the feces in the experiments with the three subjects was 42.0, 32.1, and 24.1 per cent, respectively, or a general average of 32.7 per cent, a value which agrees very closely with that found by Woods and Merrill<sup>a</sup> for a man on bread and milk diet, viz, 32 per cent. In later experiments not yet published the same authors with a different method of examination obtained much higher results. They state, however, that they consider that the ether, alcohol, and limewater method yields the most trustworthy results.

It would seem desirable and necessary to accumulate more data regarding metabolic nitrogen before drawing any definite conclusions.

### PECUNIARY ECONOMY OF FRUITS AND NUTS.

The object of this discussion is to present one side of the pecuniary economy of food, especially fruit and nuts. The composition and digestibility of nuts and fruits has been discussed in the foregoing pages, but little has been said regarding their comparative cost as sources of nutrients and energy.

The table below shows the comparative cost per pound of the total protein and per 1,000 calories of energy when furnished by different fruits and nuts and food products derived from them, and also the amount of nutrients and energy furnished for 10 cents rating the foods at certain average prices per pound. For purposes of comparison a few of the more common foods have been included also. As already noted, fruits contain very little protein, therefore no matter how low the price of the fruit per pound the cost of the protein must of necessity be high. Nuts, on the other hand, being rich in protein, would supply this nutrient at a much lower cost. The principal nutrient in fruits belongs to the group carbohydrates. Nuts are rich in fats. Both fruit and nuts therefore are sources of energy, the amount varying within rather wide limits.

TABLE 56.—*Comparative cost of total nutrients and energy in different food materials at average prices.*

Kind of food material.	Price per pound.	Cost of 1 pound protein.	Cost of 1,000 calories energy.	Amounts for 10 cents.				
				Total weight of food material.	Protein.	Fat.	Carbohydrates.	Energy.
	Cents.	Dollars.	Cents.	Pounds.	Pounds.	Pounds.	Pounds.	Calories.
Fresh fruits:								
Apples .....	1½	5.00	7.30	6.67	0.02	0.02	0.72	1,467
Apricots .....	3	3.00	11.8	3.33	.03	.....	.42	849
Bananas .....	7	8.75	23.3	1.43	.01	.....	.21	429
Cantaloupes .....	3½	11.67	38.9	2.86	.01	.....	.13	257
Cherries .....	4	4.45	11.6	2.50	.02	.02	.40	862
Figs .....	7	4.67	18.4	1.43	.02	.....	.27	543
Grapes .....	4	4.00	11.9	2.50	.03	.03	.36	837
Lemons .....	7	10.00	48.3	1.43	.01	.....	.08	207
Limes .....	2½	3.57	17.2	4.00	.03	.02	.24	580
Nectarines .....	8	13.33	28.1	1.25	.01	.....	.19	356

<sup>a</sup> U. S. Dept. Agr., Office of Experiment Stations Bul. 85.



TABLE 56.—Comparative cost of total materials and energy in different food materials at average prices—Continued.

Kind of food material.	Price per pound.	Cost of 1 pound of protein.	Cost of 1,000 calories energy.	Amounts for 10 cents.				
				Total weight of food material.	Protein.	Fat.	Carbohy- drates.	Energy.
Fresh fruits—Continued.								
Oranges.....	6	10.00	35.2	1.67	0.01		0.14	284
Olives.....	10	4.90	13.6	1.00	.02	0.14	.07	737
Peaches.....	4	8.00	25.1	2.50	.01		.19	398
Pears.....	3	6.00	11.5	3.33	.02	.01	.42	866
Persimmons.....	10	9.62	34.3	1.00	.01		.13	292
Pineapples.....	4	9.76	3.8	2.50	.01		.13	263
Plums.....	3	3.33	8.1	3.33	.03		.64	1,232
Prunes.....	3	4.29	9.0	3.33	.02		.58	1,115
Pomeloes.....	5	8.33	28.4	2.00	.01		.17	352
Pomegranates.....	10	6.66	21.7	1.00	.02	.02	.20	460
Watermelon.....	1½	7.50	25.0	6.67	.01		.18	400
Dried fruits:								
Apples.....	12	7.50	8.9	.83	.01	.02	.55	1,121
Apricots.....	10	2.13	7.75	1.00	.05	.01	.63	1,290
Citron.....	3	6.00	1.97	3.33	.02	.05	2.60	5,078
Currants.....	10	4.17	6.7	1.00	.02	.02	.74	1,495
Dates.....	10	5.26	6.9	1.00	.02	.03	.71	1,450
Figs.....	15	3.50	10.2	.67	.03		.50	988
Pears.....	12	4.28	7.4	.83	.02	.04	.61	1,357
Peaches.....	15	3.06	10.8	.67	.03		.45	926
Prunes.....	10	5.56	8.4	1.00	.02		.62	1,190
Raisins.....	10	4.35	6.9	1.00	.02	.03	.69	1,445
Jams, preserves, etc.:								
Apple.....	16	91.43	13.8	.62			.39	727
Apple sauce.....	16	53.33	40.5	.62			.12	245
Apricot sauce.....	16	8.42	16.0	.62	.01	.01	.30	620
Currant.....	16	16.00	11.9	.62			.44	836
Cherry.....	16	32.00	12.1	.62			.44	823
Currant and raspberry.....	16	26.66	12.8	.62			.42	781
Blackberry.....	16	20.00	26.2	.62			.43	378
Damson.....	16	32.00	13.0	.62			.41	768
Gooseberry.....	16	32.00	13.2	.62			.40	752
Grape.....	16	40.00	12.7	.62			.42	780
Figs (stewed).....	16	13.33	20.4	.62	.01		.25	487
Orange marmalade.....	16	26.66	10.1	.62			.52	933
Pineapple marmalade.....	16	53.33	12.7	.62			.42	785
Prune sauce.....	16	32.00	37.2	.62			.14	267
Peach jam.....	16	32.00	13.0	.62			.41	766
Pear jam.....	16	53.33	14.1	.62			.38	707
Pineapple.....	16	40.00	12.7	.62			.42	781
Plum.....	16	22.85	12.6	.62			.42	786
Quince.....	16	53.33	12.8	.62			.42	778
Strawberry.....	16	26.67	12.0	.62			.44	833
Tomato jam.....	16	14.56	13.8	.62			.38	722
Raspberry.....	16	22.85	12.3	.62			.43	810
Jellies:								
Apple.....	16	53.33	12.2	.62			.43	812
Barberry.....	16	32.00	13.5	.62			.40	742
Blackberry.....	16	66.67	14.6	.62			.37	684
Cherry, first quality.....	16	14.56	11.0	.62			.48	902
Crab apple.....	16	40.00	13.1	.62			.41	764
Currant.....	16	40.00	13.4	.62			.40	744
Grape.....	16	53.33	13.1	.62			.40	745
Guava.....	16	53.33	10.5	.62			.51	952
Huckleberry.....	16	228.57	13.8	.62			.39	724
Pineapple.....	16	40.00	13.0	.62			.41	771
Peach.....	16	80.00	13.2	.62			.40	755
Plum.....	16	32.00	13.7	.62			.39	732
Orange.....	16	80.00	10.3	.62			.39	967
Pear.....	16	100.00	12.6	.62			.43	794
Quince.....	16	80.00	13.3	.62			.40	750
Raspberry.....	16	40.00	13.3	.62			.40	753
Strawberry.....	16	53.33	13.5	.62			.39	738
Canned fruits:								
Apricots.....	16	17.78	47.1	.62	.01		.11	211
Cherries.....	16	14.56	58.9	.62			.13	257
Pears.....	16	53.33	45.5	.62			.11	220
Peaches.....	16	20.00	53.2	.62			.09	188
Pineapp e.....	16	29.10	28.6	.62			.12	350
Juices:								
Apple (fall pippin).....	20	37.04	140.8	.50			.03	71
Blackberry.....	20	37.14	133.3	.50			.04	75
Crab apple.....	20	250.00	200.0	.50			.03	50
Grape (Ives seedling).....	20	83.33	128.2	.50			.04	78
Orange (Florida navel).....	20	34.48	181.8	.50			.03	55

TABLE 56.—Comparative cost of total materials and energy in different food materials at average prices—Continued.

Kind of food material.	Price per pound.	Cost of 1 pound protein.	Cost of 1,000 calories energy.	Total weight of food material.	Amounts for 10 cents.				Energy.
					Protein.	Fat.	Carbohy- drates.		
	Cents.	Dollars.	Cents.	Pounds.	Pounds.	Pounds.	Pounds.	Calories.	
Juices—Continued.									
Peach.....	20	90.91	126.6	0.50	.....	.....	0.04	79	
Pear (Bartlett).....	20	222.22	96.2	.50	.....	.....	.06	104	
Pineapple.....	20	54.05	83.3	.50	.....	.....	.06	120	
Plum (Damson).....	20	46.51	88.5	.50	.....	.....	.06	113	
Plum (wild fox).....	20	142.85	101.0	.50	.....	.....	.05	99	
Mixed fruit.....	20	133.33	172.4	.50	.....	.....	.03	58	
Berries:									
Blackberries.....	7	5.38	25.9	1.43	0.02	0.01	.16	386	
Cranberries.....	5	12.50	23.3	2.00	.01	.01	.20	430	
Currants.....	5	3.33	18.9	2.00	.03	.....	.26	530	
Gooseberries.....	5	10.64	19.2	2.00	.01	.....	.27	520	
Huckleberries.....	4	6.67	11.6	2.50	.02	.02	.42	862	
Loganberries.....	7	6.42	26.5	1.43	.02	.....	.18	377	
Raspberries.....	7	7.00	27.4	1.43	.01	.....	.18	365	
Strawberries.....	7	7.78	40.0	1.43	.01	.01	.10	250	
Whortleberries.....	4	5.71	10.3	2.50	.02	.08	.34	975	
Nuts:									
Almonds.....	15	1.30	9.0	.67	.08	.20	.06	1,112	
Beechnuts.....	10	.77	5.5	1.00	.13	.34	.08	1,820	
Brazil nuts.....	15	1.74	9.0	.67	.06	.23	.02	1,109	
Butternuts.....	15	3.95	34.9	.67	.03	.06	.....	288	
Chestnuts.....	8	1.54	8.5	1.25	.07	.06	.44	1,181	
Cocanuts.....	5	1.72	3.5	2.00	.06	.51	.29	2,826	
Filberts.....	15	2.00	9.5	.67	.05	.21	.04	1,055	
Hickory nuts.....	9	1.55	7.1	1.11	.06	.28	.04	1,404	
Lichi nuts.....	35	20.60	40.0	.29	.....	.....	.13	254	
Peanuts.....	7	.36	3.6	1.43	.28	.42	.27	2,767	
Pecans.....	15	2.94	8.1	.67	.03	.25	.05	1,237	
Pine nuts.....	8	1.27	5.4	1.25	.08	.35	.11	1,845	
Pignolias.....	25	.75	8.8	.40	.14	.20	.03	1,138	
Pistachios.....	20	.90	6.7	.50	.11	.27	.08	1,498	
Walnuts.....	15	3.06	17.0	.67	.03	.12	.02	593	
Butters:									
Apple.....	5	10.00	5.6	2.00	.01	.....	.94	1,780	
Peanut.....	20	.68	7.1	.50	.15	.23	.09	1,412	
Beef, fresh:									
Porterhouse steak.....	25	1.31	22.5	.40	.07	.07	.....	444	
Round.....	16	.84	17.9	.62	.12	.08	.....	555	
Mutton:									
Leg, hind.....	20	1.30	22.2	.50	.07	.07	.....	445	
Loin chops.....	16	1.23	10.2	.62	.08	.20	.....	977	
Pork: Ham, smoked.....	22	1.55	13.1	.46	.06	.15	.....	770	
Fish:									
Cod, dressed.....	10	.90	46.5	1.00	.11	.....	.....	215	
Halibut, steak or sections.....	18	1.17	38.3	.56	.08	.02	.....	266	
Shad, whole.....	20	2.12	52.6	.50	.05	.02	.....	190	
Fish: Canned sardines.....	40	1.67	42.1	.25	.06	.03	.....	238	
Shellfish:									
Oysters, "solids," 50 cents per quart.....	25	4.17	108.7	.40	.02	.....	.01	92	
Crabs, 15 cents.....	15	1.90	76.9	.66	.05	.01	.....	129	
Eggs: Hen's, 24 cents per dozen.....	16	1.22	25.2	.62	.08	.06	.....	394	
Dairy products:									
Whole milk.....	3½	1.06	10.5	2.86	.09	.11	.14	925	
Cheese, cheddar.....	16	.58	7.5	.62	.17	.23	.03	1,330	
Skim milk.....	2	.59	11.8	5.00	.17	.02	.26	850	
Flour, meal, etc.:									
Entire wheat flour.....	2½	.18	1.5	4.00	.55	.08	2.88	6,700	
Gluten flour.....	15	.75	8.8	.67	.13	.02	.43	1,131	
Wheat flour, patent roller process, high grade and medium.....	2½	.22	1.5	4.00	.46	.04	3.00	6,600	
Macaroni and vermicelli.....	25	1.87	15.2	.40	.05	.....	.30	658	
Wheat breakfast food.....	7½	.62	4.4	1.33	.16	.02	1.00	2,261	
Oat breakfast food.....	7½	.45	4.1	1.33	.22	.10	.88	2,460	
Bread, pastry, etc.:									
White bread.....	5	.54	4.2	2.00	.18	.03	1.06	2,430	
Rye bread.....	5	.56	4.3	2.00	.18	.01	1.06	2,360	
Sugars, etc.:									
Sugar.....	6	.....	3.2	1.67	.....	.....	1.67	3,106	
Candy.....	20	.....	11.2	.50	.....	.....	.48	892	
Vegetables:									
Beans, dried.....	5	.22	3.1	2.00	.45	.03	1.19	3,210	
Celery.....	5	5.56	71.4	2.00	.02	.....	.05	140	
Potatoes, 90 cents per bushel.....	1½	.83	4.8	6.67	.12	.01	.98	2,068	

From the data in the above table it appears that the fruit juices are the most expensive sources of protein among the fruits and their products and that dried fruit is the cheapest, although the latter is far outranked in this respect by the nuts.

The average price per pound of the protein of nuts ranges higher than the corresponding average of meats, but the cost (36 cents) per pound of peanut protein is lower than that reported for meats, fish, eggs, milk, dairy products, prepared cereals, and gluten flour. The only foods mentioned in the table which furnish protein at a less cost than peanuts are the flours and dried beans.

The nuts are the cheapest source of energy for the strict fruitarian, the peanut ranging far ahead of any other variety. The price, 3.6 cents for 1,000 calories of energy, recorded for peanuts is considerably less than the corresponding cost noted for any of the animal foods, and is below that given in the table for potatoes at 90 cents per bushel. Wheat flour supplies energy more cheaply than peanuts, but the cost of 1,000 calories, when supplied by sugar at 6 cents and by dried beans at 5 cents per pound, approaches very closely to the cost when furnished by peanuts. The peanut deserves special mention because it is the cheapest of the domestic nuts, containing the highest percentage of protein, with maximum fuel value and minimum refuse.

As may be seen by a reference to the table, 10 cents will purchase more protein and energy when expended for the flours and meals than in any other way, but it must be remembered in this connection that these are the raw materials requiring considerable preparation before they are palatable. This is not necessary with fruits and nuts, except in the case of the peanut, which is usually roasted before it is considered palatable by most persons, though there are those who prefer it raw.

While it is true that 10 cents will buy more animal protein than fruit protein, it will on the average purchase fully as much energy when spent for fresh fruits and more in the case of dried fruits than when expended for lean meats. When considering nuts it is readily observed that 10 cents will buy about the same amount of nut protein as of animal protein, except in case of cheese and skim milk. If spent for peanuts, it will purchase more than twice the protein and six times the energy that could be bought for the same expenditure for porterhouse steak.

It is of more than passing interest to note that 10 cents worth of peanuts will contain about 4 ounces (120 grams) of protein and 2,767 calories of energy, which is more protein than that furnished by any of the diets and more energy than most of the diets used in the experiments here reported. Although peanuts supply protein and energy for a smaller sum than bread, they are outranked by dried beans, which, at 5 cents a pound, will supply for 10 cents over 200 grams of protein and 3,040 calories of energy. If more peanuts and dried beans had

been used by the fruitarians studied, the diet would have been enriched and the cost decreased.

The almond, so much in favor with fruitarians, furnishes for 10 cents about one-third the protein and less than one-half the energy supplied by peanuts.

### SUMMARY.

A review of the results of the studies of the fruit and nut diet seems to bring out the following points of interest perhaps more prominently than some others:

While some of the dietaries make it plain that it is possible to obtain the requisite amount of protein and a proper fuel value from a fruitarian diet, still the majority of those studied fell far below the tentative standards. At the same time it is not just to ascribe this entirely to the form of diet. These same people might have consumed no larger quantities of nutrients on a mixed diet.

The nutritive value of the fruitarian diet is shown most clearly in the case of the university student, who, though entirely unaccustomed to such fare, gradually changed from an ordinary mixed diet to one of fruit and nuts without apparent loss of health or strength. He was then able for eight days to carry on his usual college work and also for part of the time to perform heavy physical work on an exclusively fruitarian diet without any material loss in weight.

It would seem from the data that it was more difficult for two of the subjects to obtain the requisite amount of protein when on a limited diet of one kind of nut combined with fruits than it was when they were unrestricted and ate of a variety of each. In nearly all cases where the diet was limited in variety, consisting of combinations of one or two fruits with one kind of nuts, the subject uniformly complained of a constant craving for something else, as green vegetables or cereals. At such times it was found that the coefficients of digestibility were lower than those recorded when the subject ate some vegetables or cereals which made the diet more appetizing.

The dietaries which included cereals furnished more protein and energy in most cases than those which were limited strictly to fruit and nuts.

The chief sources of nutriment in fruits are the carbohydrates, which, judging by results of the experiments here reported, possess a coefficient of digestibility only slightly lower than the carbohydrates of the mixed diet.

The cost of the food per person per day in the nine dietary studies varied from 18 cents to 46 cents.

The amount of nitrogen excreted in the urine was small, as would be expected when the diet contains so little protein. Nitrogen equilibrium was maintained in 14 of the 31 digestion experiments, and in



some cases this was done with a smaller amount of protein than was usually consumed by the same subject during the dietary studies.

The feces excreted per day during the digestion experiments were less in amount than has been noted in some experiments with a mixed diet or a diet of bread and milk. This is contrary to what has been found usually with a vegetarian diet made up of bread and other cereal foods, garden vegetables, etc., and containing little or no fruit and nuts. The percentage of so-called metabolic nitrogen in the feces examined did not exceed that found by other investigators in feces from a bread and milk diet.

Although it is undoubtedly advisable to wait until more data have been gathered before making definite statements regarding the digestibility of different fruits and nuts, enough work has been done to show that they are quite thoroughly digested and have a much higher nutritive value than is popularly attributed to them. In view of this it is certainly an error to consider nuts merely as an accessory to an already heavy meal and to regard fruit merely as something of value for its pleasant flavor or for its hygienic or medicinal virtues.

As shown by their composition and digestibility, both fruit and nuts can be favorably compared with other and more common foods. As sources of carbohydrates, fruits at ordinary prices are not expensive; and as sources of protein and fat, nuts at usual prices are reasonable.

In the present investigations the question of the wholesomeness of a long-continued diet of fruit and nuts is not taken up. The agreement of one food or another with any person is frequently more or less a matter of personal idiosyncrasy, but it seems fair to say that those with whom nuts and fruits agree can, if they desire, readily secure a considerable part of their nutritive material from such sources.





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- Some Results of Dietary Studies in the United States. By A. P. Bryant. Reprinted from Yearbook of Department of Agriculture for 1898. Pp. 14.
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